FRACTURES
OF THE
LOWER EXTREMITY OR BASE
OF THE
RADIUS

LEWIS STEPHEN PILCHER

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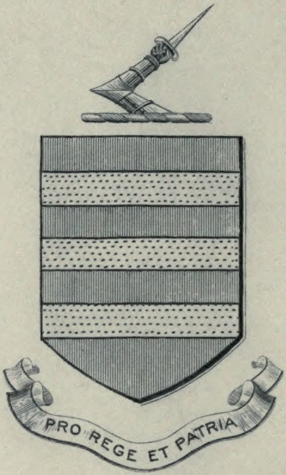

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LOWER EXTREMITY OR BASE
OF THE
RADIUS

BY
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FRACTURES OF THE LOWER EXTREMITY OR BASE OF THE RADIUS

FRACTURE of the lower extremity or base of the radius is one of the most frequent surgical conditions that the medical practitioner has to treat. The writer had his own interest first awakened in it as a boy when one of his playmates fell upon his outstretched hand and was picked up with a "broken and crooked wrist." When immediately after graduation he spent some months in a country district looking for practice, he found it when one of his neighbors fell out of an apple tree and sustained a wrist fracture. Again, when some years later, he essayed his fortune in a city he was helped mightily by a friend who had the misfortune to fall down a flight of icy steps one wintry day, and fractured the base of his radius, and by a boy in his neighborhood who, while flying a kite from the roof of a shed, forgot himself, walked off the roof, fell to the ground and wrenched off the lower epiphysis of his radius with extreme displacement. (The condition of this wrist twenty years later is shown in Fig. 110, *q.v.*)

In a service as attending surgeon in the Outdoor Department of a large hospital, which I enjoyed for a period of ten years, 1873–1883, fractures of the base of the radius formed a constant item. The interest thus awakened in that particular injury led me to give to its observation and study much care. Beside a perusal of the literature of the subject, many dissections and experiments on the cadaver were made; specimens in the museums of various hospitals were freely placed at my disposition by their curators for study. In particular a visit to the collection made many years before by Robert William Smith in Dublin, on which was based the treatise of that surgeon on "Fractures in the Vicinity of Joints," was instructive. In the early part of 1878 I published my first paper (Reason *vs.* Tradition in Treatment of Certain Injuries to the Wrist-joint) on the subject in the *Proceedings of the Medical Society of the County of Kings*, and in May of that year had the opportunity of reading a paper on the same subject, and making an experimental demonstration on the cadaver before the New York Academy of Medicine. In May, 1880, I published a "Further Contribution to the Study of Fractures of the Inferior Extremity of the Radius, etc. (*Proceedings of the Medical Society of the County of Kings*, 1880).

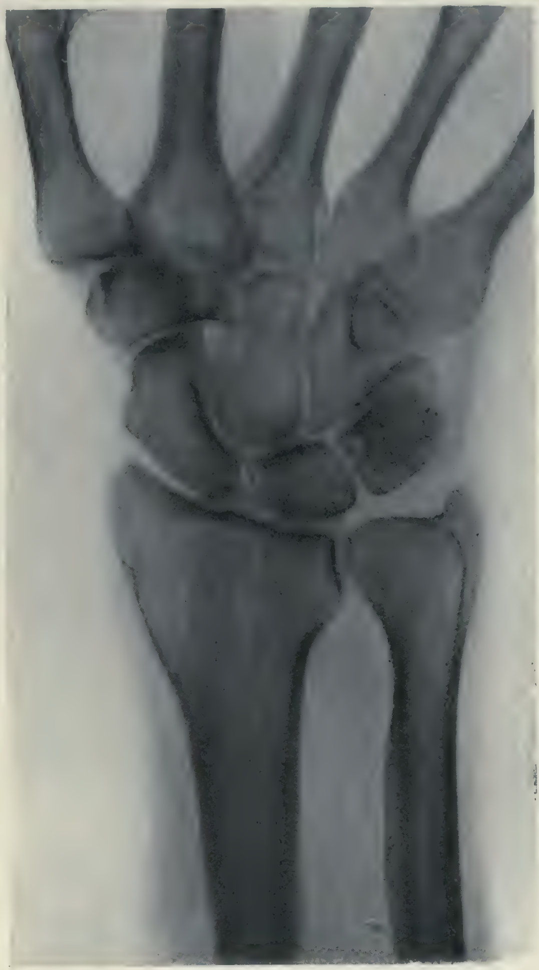


FIG. 1.—The base of the radius and the bones of the wrist—skiagraph of normal bones, anteroposterior view.

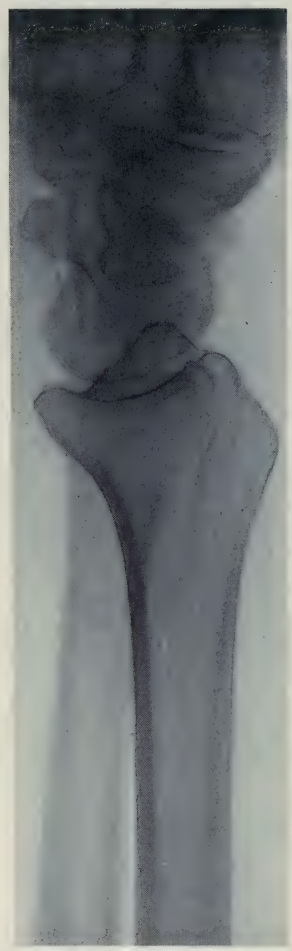


FIG. 2.—Transverse view of the normal base of the radius (skiagraph).

In the period which has passed since these publications, more than thirty-six years, my interest in the subject has continued, although in the nature of things other departments of surgical work have engaged more of my attention. I am now returning once more to this subject to make a final contribution to it, in which I hope to embody the mature conclusions of these later years. During this period the Röntgen ray has been added as a source of surgical diagnosis and of observation. Upon no subject has it shed a clearer or greater light than upon wrist-joint injuries. It has been a matter of very great satisfaction to me to find that its revelations have been so markedly confirmatory of the conclusions reached before its assistance was enjoyed. As will be seen in the following pages, I have made full use of the wealth of information which the X-ray skiagrams have produced. Many of these were taken by Doctors Cole and Eastmond and by them freely placed at my disposal. The late Carl Beck was an enthusiast both in the matter of X-ray and in the study of fractures of the lower extremity of the radius, and his valuable material was also generously given to me before

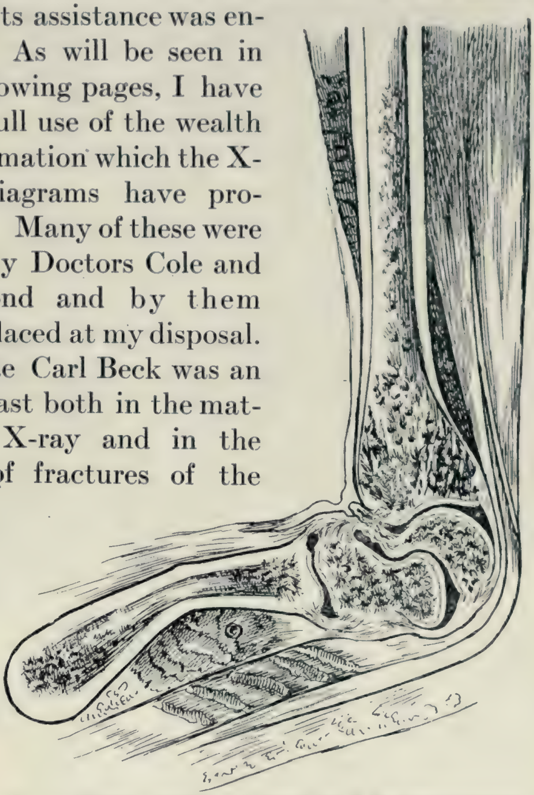


FIG. 3.—Showing relation of the elements of the wrist-joint when the hand is in moderate dorsal flexion (*i.e.*, extension).

his death. The X-ray department of my own private hospital has more recently supplemented and extended the studies for which, before, I had to depend on the goodness of my colleagues.

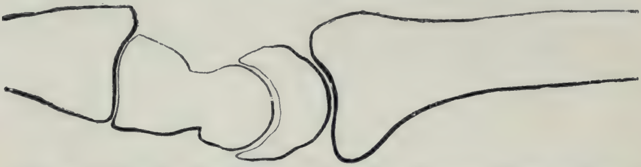


FIG. 4.—Outline from longitudinal section of wrist bones, cut passing through base of radius, semilunar, os magnum and metacarpal bone. Note the projection of the anterior lip of the base of the radius.

Naturally I have read with interest the chapters devoted to this injury which have been found in the various treatises on fractures that have appeared during the last quarter of a century; the sound and careful studies of John B. Roberts and the brilliant and convincing work of Scudder deserve special mention among these, but I have not felt that even by these men the last word has yet been said on the subject in question. I am not vain enough to think that I am myself to say this last word,

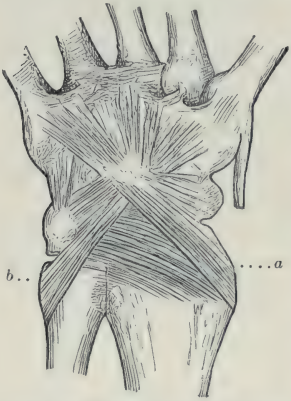


FIG. 5.—Showing the arrangement of the fibres of the anterior common ligament of the wrist-joint. (After Henle.) Note particularly the oblique fasciculi, *a* and *b*, which pass from the midcarpus outward and upward to be inserted respectively into the styloid process of the radius and of the ulna.

but I am persuaded that there is still some room for further clarifying and systematizing knowledge and teaching in this field, and as an effort in this direction I offer this contribution.

It may be noticed that I do not use at all the name of the distinguished Irish surgeon which for a hundred years has commonly been attached to this injury. I am influenced in this way by two reasons—one, that names descriptive in anatomical or pathological terms of a surgical condition are much to be preferred when it is possible to phrase them, and, second, because the use of the name in question has been so associated through all these years with erroneous views of the nature and cause of the injury that its continued use tends to hinder the general acceptance now of more accurate knowledge.

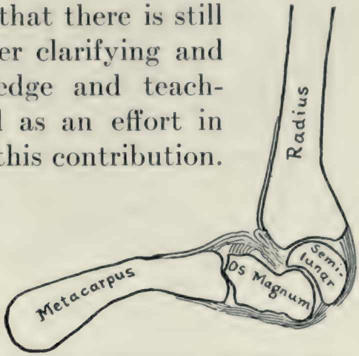


FIG. 6.—Hand in extension: Note the relaxation of the posterior radiocarpal ligament; the rotation and forward projection of the carpal bones, and the tension upon the anterior radiocarpal ligament.

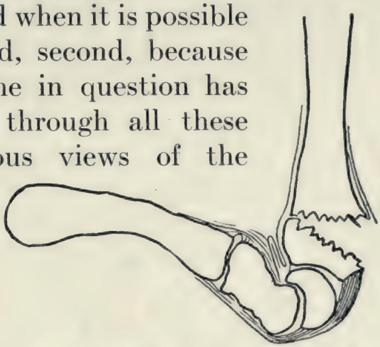


FIG. 7.—Extending force continued : result, extreme backward flexure of the wrist and disruption of the lower end of the radius, the fragment torn off being more or less of that part into which the anterior ligament is inserted.

That fractures of the lower extremity or base of the radius should be of frequent occurrence one appreciates when the mechanism of its usual production is understood. A fall, and the force of the fall broken by an outstretched arm with hand in extension, are the usual conditions from which it results. In the course of such an accident, forcible bending back of the hand with overtension of the anterior common ligament of the carporadial joint is produced. Strain is brought to bear on the projecting anterior lip of the lower end of the radius (Figs. 3–5). The slipping first row of carpal bones as it moves in the cup-like cavity of the lower articular surface of the radius furnishes the mechanism through which the force is transmuted into a cross-breaking strain upon the bone into which the ligament is inserted, with the result that that portion of the bone is torn off (Figs. 6 and 7).

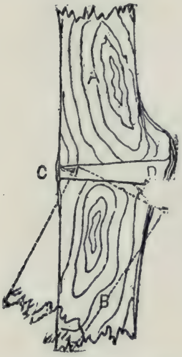


FIG. 8.—The elements of the wrist-joint represented as levers, *A* and *B*.

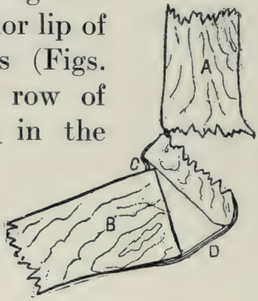


FIG. 9.—Fracture of lever *A* by cross-breaking strain upon lever *B*.

Examine a longitudinal section through the wrist-joint from the middle of the radius to the middle of the third metacarpal bone (Figs. 3–4). The section passes through the semilunar and the outer portion of the os magnum. The carpal bones and the metacarpal are joined together with such firmness that but slight motion is permitted between them. In the movements

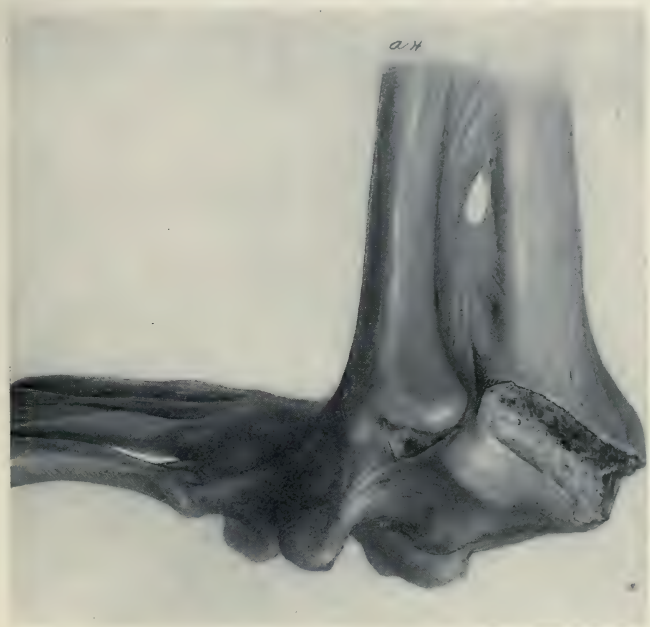


FIG. 10.—The force is transformed into a cross-breaking strain, with the result that the lower end of the bone is torn off (drawing from an experimental specimen).

of extension and flexion at the wrist they act virtually as one bone. At the lower extremity of the radius projects anteriorly a prominent lip, into which is inserted the anterior radiocarpal ligament (Fig. 5), the extent of insertion of whose fibres is continued for a quarter-inch or more above the articular margin. This ligament, though dense and strong, is sufficiently loose to permit considerable latitude of motion backwards of the carpus upon the radius (Figs. 3 and 6). The posterior radiocarpal ligament unites the bones together behind similarily.

The bones thus related constitute two levers. They may be represented as in the accompanying diagram (Fig. 8) by *A* and *B*, held together by bands at *C* and *D*. When *B* is forcibly carried backwards (extension of the hand), the band *D* is made

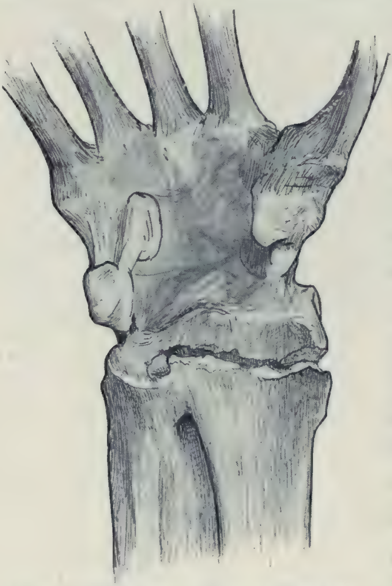


Fig. 11.—Experimental fracture, transverse.

tense; the opposite border of the lever, having slipped forward as far as the band *C* will permit (*cf.* Fig. 3), now abuts against the lower surface *A*, which becomes a fulcrum for the further action of the lever. The mechanical arrangement is such that an immense power may be exerted. If the backward force continues to act, either the band *D* must rupture or a lever be fractured. The projecting lip upon the upper lever puts it at a disadvantage. The band continues to sustain the strain. The lever gives way (Fig 9). The point of fracture is necessarily just above that portion of the lever controlled by the band. The strain upon the lever is nearly

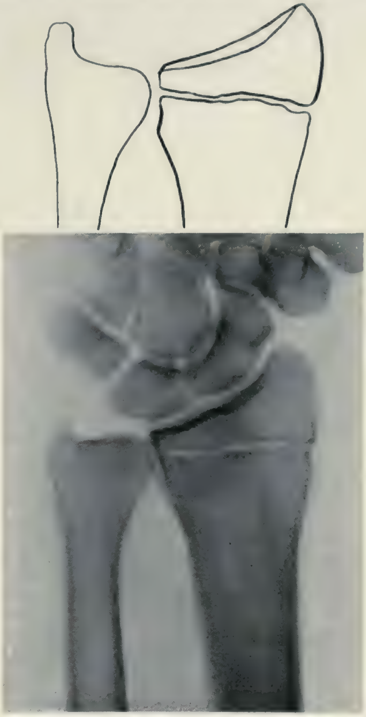


Fig. 12.—Traumatic fracture, transverse.

transverse to its long axis. By this the direction of the line of fracture is determined. A fracture has been produced by definite forces, at a definite point and in a definite direction. These are practically the conditions which unite in the production of the more common fractures of the inferior extremity of the radius.

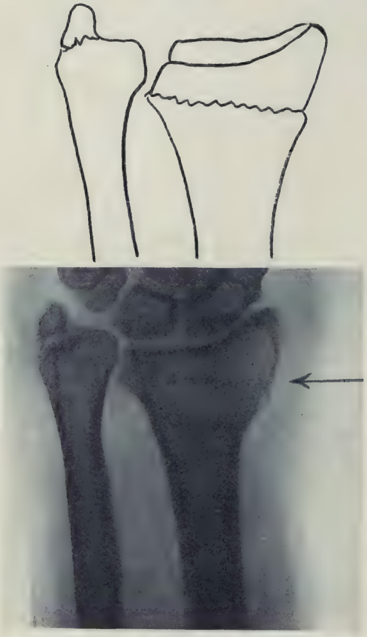


FIG. 13.—Arrow points to line of fracture; lateral view shows radial fragments separated in front, but still held by periosteum behind as by a hinge; angle of separation partly filled with callus. Ulnar styloid fractured.

By the powerful leverage which the extended hand and carpus obtain through the strong anterior ligament upon the lower end of the radius, that portion of the bone is literally torn from it (Figs. 7 and 10). The very arrangement of the expanded end, with its cancellated structure, which so admirably fits this portion of the bone for receiving and breaking any shock directly transmitted to it, renders it the less able to resist a force of avulsion. The combination of conditions is such as to make the bone, when submitted to such a strain, weaker than the ligament, and the fracture of the bone accordingly takes place.

Experimental Demonstration. — The truth of this may be easily tested experimentally upon the fresh cadaver by simply bending the hand backward strongly, while the forearm is firmly held, until some structure gives way; this will usually be accompanied by a sharp snap. Upon dissection it will be found that as a rule the anterior ligament of the wrist has remained intact, while the radius has been fractured, the line

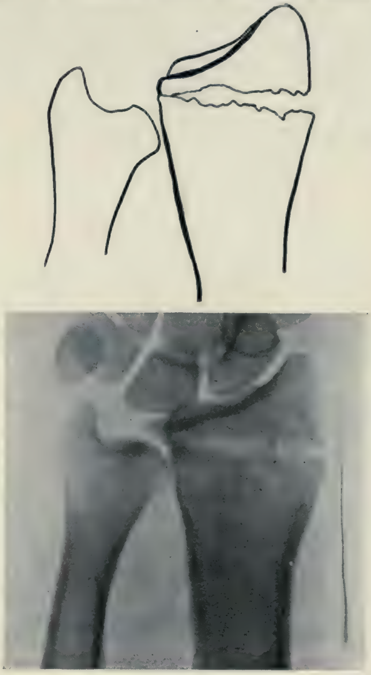


FIG. 14.—Line of fracture somewhat oblique.

of fracture anteriorly being found rarely at a point higher than a half inch above the articular edge (Fig. 10). In some instances the ligament will be found to have given way and the radius to have remained intact. In some instances where this occurs, a fracture of the scaphoid or semilunar is produced (Figs. 16 and 25). The lower fragment of the radius in those cases where fracture of that bone has been produced will vary in its shape and in the direction of the line of fracture which it presents. This will be found to bear a constant relation to the strength of the different fasciculi which compose the anterior radiocarpal ligament. In this ligament (Fig. 5) three distinct sets of fibres may be

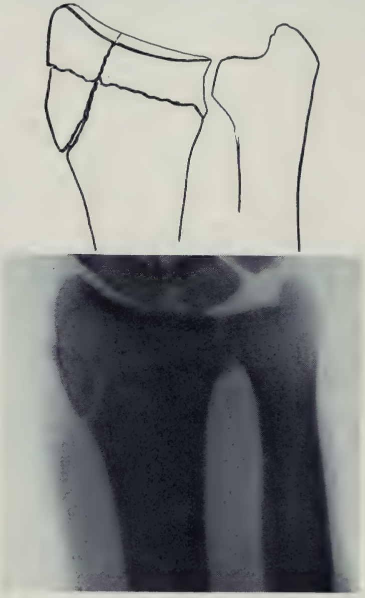


Fig. 15.—A second line of fracture runs from junction of outer and middle thirds, transverse line upward to base of styloid process. Lateral view shows moderate backward displacement of lower fragments. Mass of callus on dorsal aspect.

traced, the anterior surface of the scaphoid, semilunar and cuneiform bones affording a common origin; one set (Fig. 5) pass obliquely outward to be inserted into the styloid process and the adjoining anterior margin of the lower end of the radius, these form a dense and strong band, the strongest portion of the ligament; a second set (Fig. 5) pass obliquely in the opposite direction and are inserted into the styloid process and anterior margin of the lower end of the ulna; this band is likewise strong and dense; the third set, forming a broad and less dense band, pass directly upward to be inserted into the greater part of the anterior margin of the lower end of the radius. If both remain

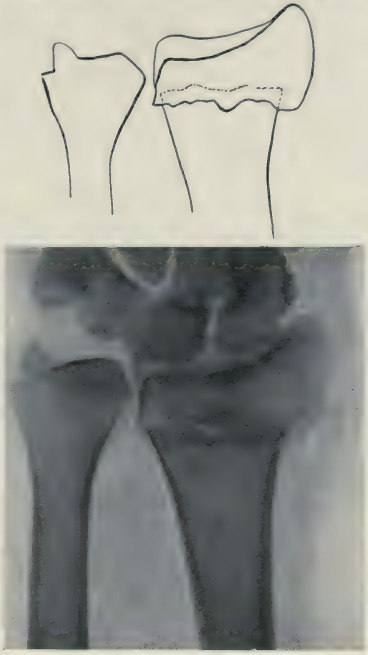


FIG. 16.—Transverse fracture about one-half inch above articular surface. Backward and outward displacement. Fracture of the scaphoid.

untorn — the most frequent condition — the whole of the articular extremity will be torn off, and a nearly transverse line of fracture be produced (Figs. 10–19). If any part of the ligament gives way it will begin from the ulnar side of the middle fasciculus, and only that part of the bone whose attached fibres remain intact will be torn off, producing a very oblique line of fracture (Figs. 20–31), the obliquity running upward and outward from the articular surface to the outer margin of the bone; thus only a bit of the styloid process may be torn off (Figs. 20–23), or a triangular fragment involving the outer half or two-thirds of the articular surface (Figs. 24–31). The variations in the degree of tonicity and thickness of the ligamentous bands, and in the shape of the articular expansion of the base of the radius, and in the arrangement of its constituent bony

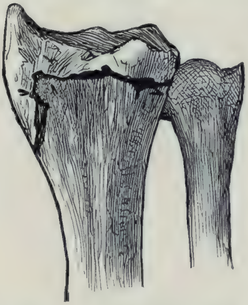


FIG. 17.—Transverse fracture in a man of nineteen years who fell a distance of 40 feet. In front the line of fracture is along the epiphysial line; thence it runs backward and upward so that on the dorsum the line of fracture is one inch above the articular edge. The lower fragment is comminuted. (Anterior view.) (N. Y. Hosp. Mus. No. 124.)

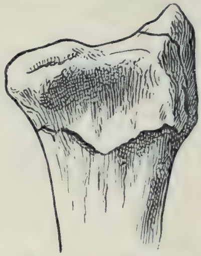


FIG. 18.—Transverse fracture with wedge impaction of upper into lower fragment. Comminution of lower fragment. (McGraw's Case, *Annals Anat. & Surg.*, vol. iii, 116.)

lamellæ will in the nature of things always more or less modify the results of the avulsive force exercised by the strain on the anterior common ligament of the wrist.

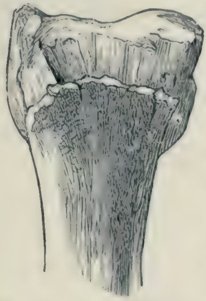


FIG. 19.—Transverse fracture with marked backward tilting of lower fragment. (Anterior view.) (N.Y. Hosp. Mus. No. 123.)

Such experiments upon the cadaver are a more severe test than are the conditions afforded by a fall sustained by a living person, for in the tissues of the cadaver the tonicity of the soft parts present in life is absent and a certain degree of relaxation of the periarticular tissues is present, as the result of which the ligaments which are put under strain must stretch some and lessen to that degree the power of the cross-breaking strain that they transmit to the radius.

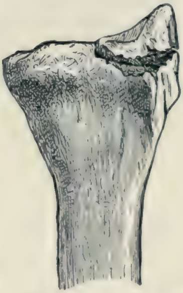


FIG. 20.—Experimental fracture. Central portion of anterior ligament of wrist ruptured.

Similar experimental tests of the results of forced backward flexion (extension) of the hand in the living are, however, occasionally presented, *e.g.*, the case published by MacLeod in the *British Medical Journal* of July 12, 1879, p. 39. The case was this:

A young man contended with an older and stronger man in a test of strength by placing elbows on a table, interlocking fingers, and then pressing back upon each other, palm to palm. The hand of the young man became violently extended until finally something gave way, with development of sharp pain in the radius and with the well-marked deformity characteristic of fracture of the inferior extremity of that bone.

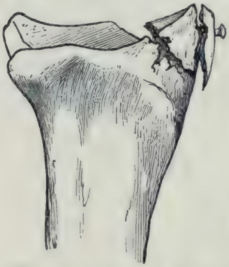


FIG. 21.—Tip of styloid process broken off; scaphoid was also fractured transversely at its middle. Result of fall from top of a derrick. (N. Y. Hosp. Mus. No. 125.) See Fig. 34.

Or as in another instance under my personal observation, a young woman, while standing on a chair, slipped and falling caught at a table to save herself. The fingers only of the outstretched hand reached the edge of the table, and the result of her effort was to have her hand bent strongly backward. Upon recovering herself she found her wrist was injured. When seen by me shortly afterward a fracture of the lower extremity of the radius was unmistakable.

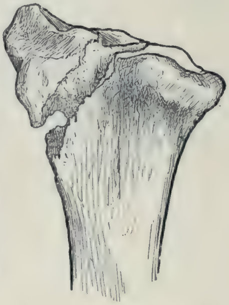


FIG. 22.—Experimental fracture, oblique from centre of carpal surface to base of styloid process.

Or as in this case: A young boy fourteen years of age, while endeavoring to prevent a boat from chafing against a dock, had his right forearm so caught between the boat and the dock that the boat impinged against his elbow while his hand was pressed against the dock. The hand was thus forced into extreme extension. I saw him within an hour after the injury. The right hand presented the characteristic silver-fork deformity of fracture of the lower extremity of the radius, and examination revealed a transverse fracture about one-half an inch above the articular surface with backward displacement of the lower fragment.

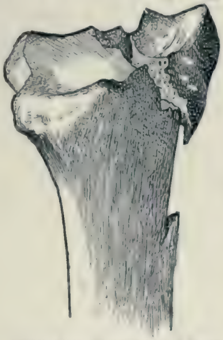


FIG. 23.—Fracture of base of styloid process (N. Y. Hosp. Mus. No. 127.)

Or as in the case of a boy of sixteen years, who, while assisting in lowering a box of tobacco down a staircase, had to support for a moment the whole weight of the case upon his extended hands as he attempted from below to prevent it from falling upon him. Immediately he realized that his left wrist had been injured. When I saw him upon the fol-

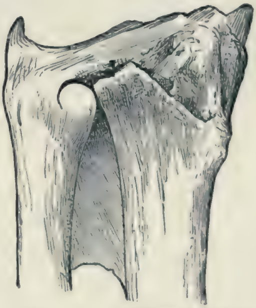


FIG. 24.—Oblique fracture running from junction of inner and middle thirds of articular surface of radius to a point seven-eighths of an inch above tip of styloid process. Lower fragment comminuted. (Anterior view.) (N. Y. Hosp. Mus. No. 122.)

lowing day I found that the inferior extremity of the left radius was fractured, the line of fracture running transversely less than one-half inch above the articular edge; the lower fragment was slightly displaced backward.

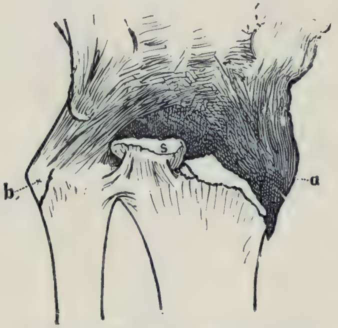


FIG. 25.—Oblique fracture running from ridge on middle of carpal articulating surface to base of styloid process. Transverse fracture of semilunar bone. Fracture of styloid process of ulna. (Wm. Hunt, *Annals Anat. & Surg.*, vol. iii, 112.)

This group of experiences occurred within the space of a few months in 1879 and were recorded by me then. Since that time, however, the extensive use of motor-boats and of automobiles has furnished on a large scale a succession of experimental demonstrations of the effects of overextension of the hand in those frequent fractures of the lower extremity of the radius which have resulted simply from the sudden recoil or "kick-back" of the crank of a gasoline explosion engine, by which the hand of the cranker is violently bent backward (Figs. 28 and 60).

The Force of Impact.—In the ordinary accidents resulting in a fracture of the base of the radius, other factors additional to that of avulsion enter. The most important of these is that remnant of the forward and downward impulse of the lower end of the radius, a force compounded of the weight of the body and the velocity of the fall which has been sustained, which remains after the force of avulsion, at first exercised by it, is expended.

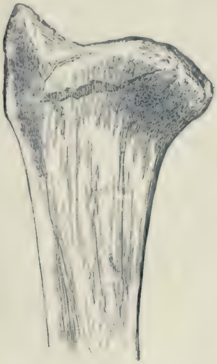


FIG. 26.—Oblique experimental fracture.

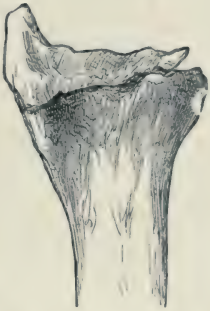


FIG. 27.—Oblique traumatic fracture. (N. Y. Hosp. Mus. No. 121.)

When the lower fragment of the radius has been torn off it becomes virtually a part of the carpus with which it moves and by which it is carried backward (Figs. 32 and 33).

Forces of Cleavage.—(*A.*) *Perpendicular wedge-like impact of the carpus against the articular cup of the base of the radius.* It is conceivable that in the case of a sudden and violent fall the force of which is sustained by the hand the rounded articular surface of the carpal mass, before the movement of backward flexion is completed, may be driven up against the concave articular surface of the radius with such force as to split it or perforate it and cause stellate longitudinal lines of fracture in the radial base. As a matter of fact, that this does occur at times is proven by postmortem dissections and in X-ray plates. The action of this force is seen very clearly in Figs. 35 to 50 given

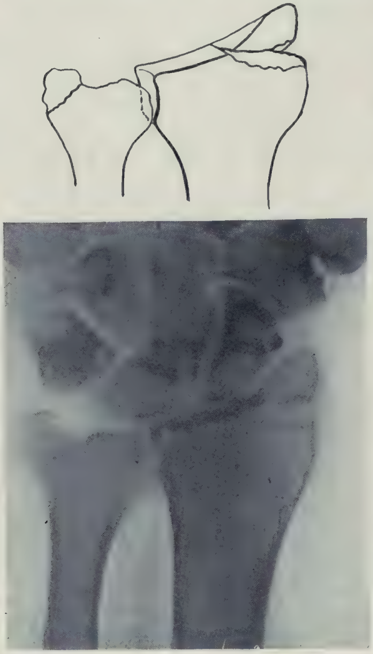


Fig. 28.—Fracture of styloid process of radius and of ulna (automobile crank kick-back). Lateral view shows a crush of the posterior lip of the radial articular surface.

herewith, which are from dissected specimens or from X-ray photographs.

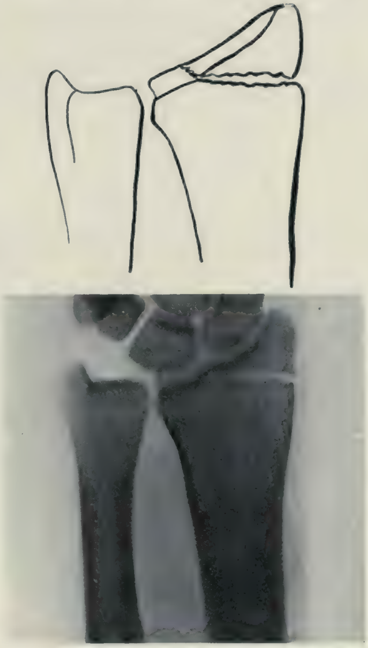


FIG. 29.—From middle of carpal articular facet to the base of the styloid process. No displacement.

(*B.*) *Splitting of the lower fragment by descent into it of the lower end of the upper fragment.* More frequently, however, indeed very frequently, the lower fragment of the radius is split into fragments by the descent into it of the lower end of the upper fragment or shaft after the transverse lesion has been accomplished. This impaction of the upper fragment into the lower one is generally present when the momentum of the fall has been great, as in falls from a height, and the extent of the impaction is a fair index of the force which the elements of the wrist have had to sustain—the greater the space through which the fall has had its course the greater the velocity attained by which the weight of the body is to be multiplied in producing the resultant force. The friability of the particular bone involved also is a factor that modifies the result in any given case. Falls from a tree, from a ladder, from a second-story window, from a carriage, down a staircase — these are common conditions in which the outstretched hand receives the first brunt of a severe impact upon the ground of the falling body. In this class of cases the lower end of the radius is not only torn off, but as a part of

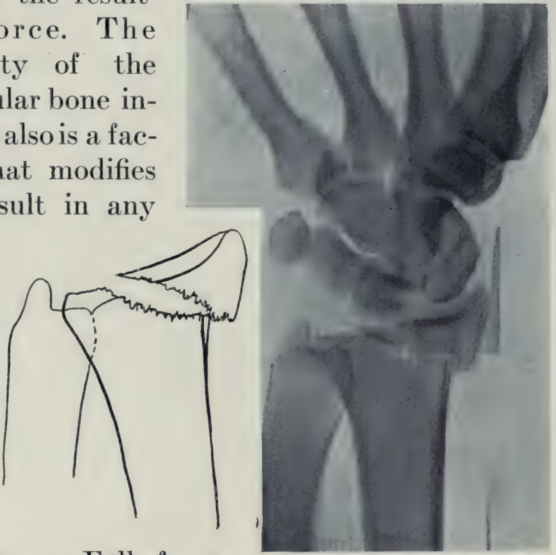


Fig. 30.—Line of fracture begins three-fourths inch toward ulnar side of carpal facet and passes outward with slight obliquity to the base of the styloid process.

the train of events, absolutely though infinitesimally later in point of time, the upper fragment, if the backward movement of the lower fragment has not been great enough to carry it clear of the broken surface of the upper fragment, is driven into the lower fragment and splits it into secondary fragments more or less numerous.

This splitting of the lower fragment by the descending upper fragment is well shown in Figs. 51 to 56 and 62 to 65. Most instructive also in this connection is a comparison of the two specimens shown, respectively, in Figs. 60 and 61. In both cases the subject was a powerful, large-boned man. Fig. 60 shows the effects of a simple forcible backward flexion at the wrist caused by an automo-

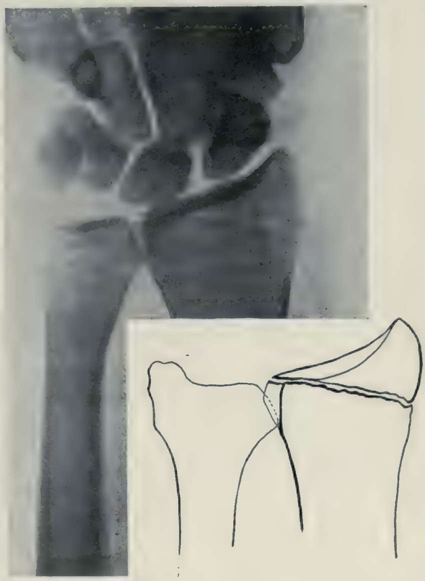
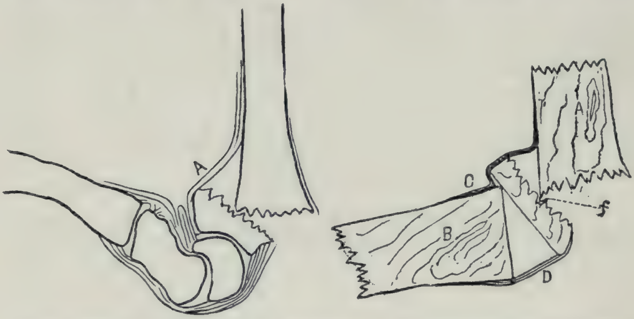


Fig. 31.—Line of fracture from junction of ulnar and carpal facets to base of styloid process. Lateral view shows hiatus between the fragments in front while they are still held together by periosteum behind.

bile crank kick-back. The lower end of the radius has been torn off but the displacement has been very slight and there is no tendency to impaction. Fig. 61 shows the effect of a fall from a ladder at a height of ten feet or more above the ground. The lower end of the radius has not only been torn off, but the carpus has been carried markedly backward and outward (see also Fig. 96 which gives a lateral view of the same case). The lower end of the upper fragment or shaft has been driven into the lower fragment and has split it. The head of the ulna has been torn from its attachment to the radius and has been forced downward and outward. Note particularly the difference in the relations of the ulna to the radius and carpus in



Figs. 32 and 33.—Illustrating mechanism of the backward displacement of lower fragment of radius produced by resistance of wrist and hand resting upon the ground to force transmitted through forearm; periosteum (*A*) stripped up from back of upper fragment and still connecting the two fragments; impaction of upper into lower fragment probable; hand still in primary position of backward flexion.

the two cases. Finally, the styloid process of the ulna has been torn off.

Explosive Splitting of Lower Fragment of Radius.—In the course of the examination of numerous skiagraphs of injured wrists I have observed in certain more rare instances that the usual backward displacement of the upper fragment has not taken place before the denser cylinder of the upper fragment has been driven down into the cancellous tissue of the lower fragment with such force that the pieces into which the lower fragment has been split are driven off in various directions, to the palmar as well as to the dorsal sides. This necessarily causes marked shortening of the radius and outward protrusion of the head of the ulna. Figs. 62 to 65 are examples of this explosive splitting of the lower radial fragment.

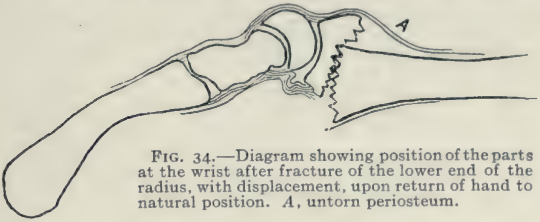


FIG. 34.—Diagram showing position of the parts at the wrist after fracture of the lower end of the radius, with displacement, upon return of hand to natural position. *A*, untorn periosteum.

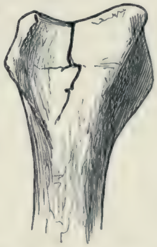


FIG. 35.—Longitudinal fissure running upward from articular facet. Result of fall from top of a derrick. Ulnar aspect of specimen shown in Fig. 21.

Backward Displacement of the Lower Fragment of the Radius.—The usual, the typical displacement that characterizes the ordinary fracture of the lower extremity of the radius, is a movement toward the dorsum of the lower fragment. This is the chief cause of the deformity which proclaims the fracture (Figs. 66–69). The carpus as it is pressed upwards and backwards by the impact of the fall tends to carry with itself the fragment of the radius which has been torn off, and the extent to which such displacement may go is limited only by the resistance of the fibrous bindings that hold the parts together and the magnitude of the force that the fall has produced (see Figs. 32, 33, 34 and 69). Various degrees of this backward displacement are shown in Figs. 70 to 99, inclusive. In the bones shown in Figs. 77 and 78, the lower fragment is seen to have been torn from the shaft and moved downward and backward on its palmar side, while

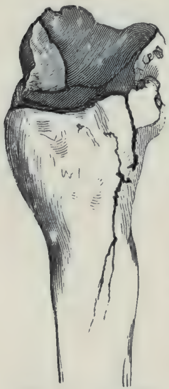


FIG. 36.—Longitudinal fissure without transverse fracture. (Bigelow.)

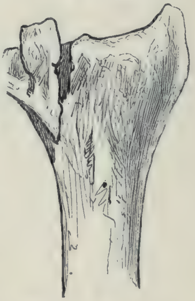


FIG. 37.—Ulnar facet split off by longitudinal fissure. (N. Y. Hosp. Mus. No. 128.)

its posterior edge is still held by the periosteum as by a hinge. The result is an anterior gap in the radius which has later been filled with callus, and thus the plane of the carpal articular surface has been materially and permanently changed. The same condition of incomplete tearing away of a thin scale from the base of the radius, the fragments being still held together on the dorsum, is well shown in Figs. 82–84. In Fig. 81, *A*, *B*, *C*, an outline in red of a normal radius has been superimposed on the outline of the injured radius (Figs. 77, 78 and 80) to show this alteration in the plane of the carpal articular surface produced by the injury. If one bears in mind the normal outline of the base of the radius (Fig. 1 and 2) the changes in its contour resulting

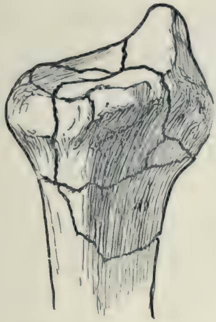


FIG. 38.—Multiple longitudinal fissures of base of radius, result of a fall while walking, in the person of a woman between fifty and sixty years of age. Death on sixth day from pulmonary œdema. No impaction of fragments at time of autopsy. (Personally communicated by Dr. Lewis A. Stimson. Letter May 26, 1881.)

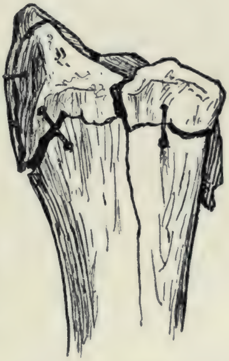


FIG. 39.—Multiple longitudinal fissures of base of radius, from specimen loaned (July 16, 1879) by Dr. Frank H. Hamilton, and received by him from Dr. W. H. Van Buren. Anterior face. For condition of articular face see Fig. 42.

from the ordinary fracture will readily be appreciated and the reason for the change will be understood and what can or cannot be done by treatment in the way of restoring the normal condition of the wrist may be demonstrated.

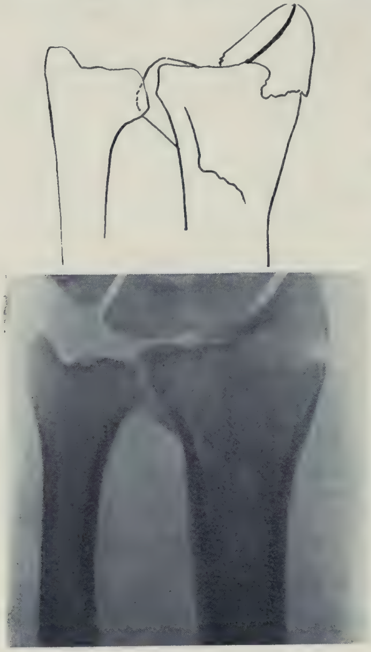


FIG. 40.—Oblique articular fracture complicated by longitudinal fissure through ulnar facet with lines of comminution visible within the carpal facet. Lateral view shows the line of transverse fracture, about half way through the thickness of the bone changes its direction to one running abruptly upwards for one inch, thus splitting away a mass from the posterior lip. This fragment is comminuted.

In the ordinary fracture, occasioned by a moderate force, the backward movement of the lower fragment is arrested before the fragment is carried to a plane entirely beyond that of the end of the shaft above. This is always the case where impaction of the one into the other is present. In many cases, however, this interlocking of the two fragments cannot properly be called an impaction, but is rather to be described as an entanglement of the irregular and serrated surfaces of the fracture masses into the irregularities one of the other. Figs. 70 to 88, inclusive, illustrate this lesser degree of displacement.

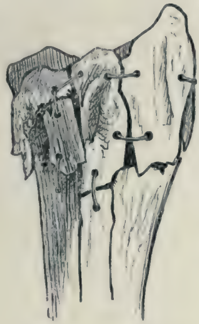


FIG. 41. — Multiple longitudinal fissures. Posterior face of Fig. 39.

In Figs. 89 to 96 the most extreme degree of backward displacement is shown. The broken off lower fragment of the radius has been carried so far back that it lies entirely posterior to the upper fragment, the lower end of which it overrides. Such a degree of displacement, although not common, is by no means rare of occurrence. The case depicted in Figs. 91, 92 and 93 has this interesting and instructive history:

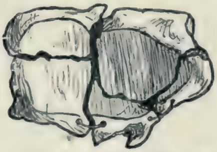


FIG. 42.—Articular face of specimen shown in Figs. 39 and 41.

A young man had sustained an injury to the wrist in the usual way without marked displacement; its full character was not appreciated and at the end of three weeks he had so far recovered that he ventured to indulge himself in a game of "hand-ball," a game in which the hand is continually thrown into violent extension in receiving and returning the ball. In the course of the game his injured wrist suddenly displayed an extreme degree of disability and deformity. A skiagraph then taken revealed the condition shown in the figures. It was evident that a fracture without displacement had taken place three weeks before and that now in the course of the repeated violent hyperextensions of the wrist called for in the playing of the game, the newly formed callus bond had given way and the final marked displacement had occurred.

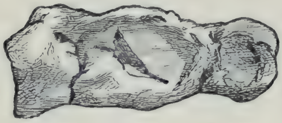


FIG. 43.—Showing dent in articular cup of radius from impact of carpus.

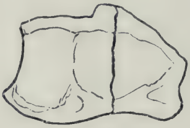


FIG. 44.

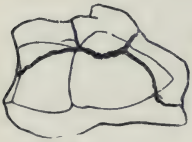


FIG. 45.

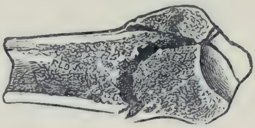


FIG. 46.—Showing manner in which the lower fragment may be split by the penetration into it from above of the upper fragment.

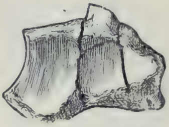


FIG. 47.—Lines of fissure in articular face of carpal cup of FIG. 46.

Outward Displacement of Lower Fragment.—The immediate effect of the giving way of the radius and the backward slipping of the carpal fragment is a movement of rotation, in the direction of supination, of the carpal mass around the head of the ulna. Not infrequently the strain upon the carpo-ulnar ligamentous fibres (Fig. 5, *b*) is so great that the styloid process of the ulna is torn off (Figs. 25, 28, 48, 49, 53, 54, 57, 61, 71, 96, 105). The broken lower end of the shaft of the radius is thrust forward and the expanded lower articular fragment is made to appear to have moved laterally.

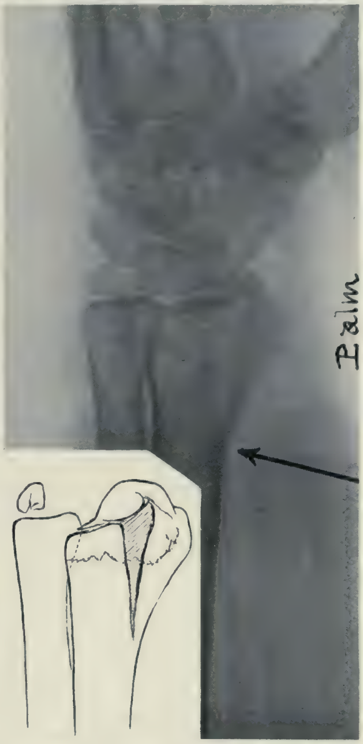


FIG. 48.—Longitudinal fissure from centre of carpal articular facet, running upwards for one inch, where it approaches the palmar surface of the radius (arrow). The lower part of this fragment is displaced forward but above the fragments are held together.

This is seen very clearly in such Figs. as 55, 56, 57, 61, 90, 92, 93, 96, 97, 98, 99. There is undoubtedly some lateral movement, but the chief element is the one of supinating rotation which brings the lower fragment into lateral relief. The lateral movement is also well shown in the specimen represented in Fig. 98, which is an old healed fracture found in a dissecting room subject. The slightest suggestion of it is visible in Fig. 60, a case in which there was a minimum of displacement of the fragments.

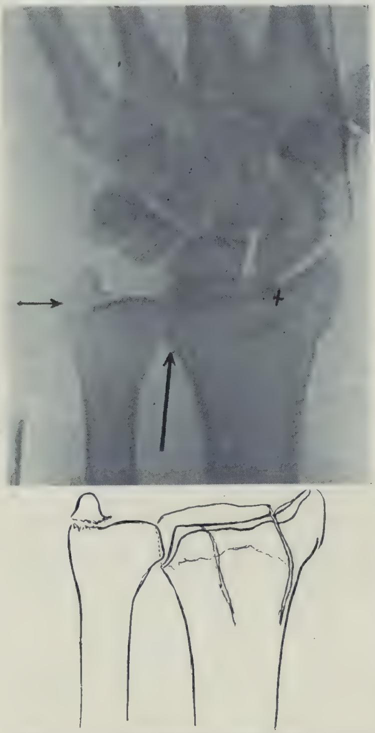


FIG. 49.—Longitudinal fracture (split) of the base of the radius. Line of split (x) visible running transversely along the carpal articular facet, continuing into a fissure running upwards through the ulnar facet (arrow). Ulnar styloid torn off.

I have, however, seen one case in which, fourteen weeks after a fracture of the base of the radius had been manipulated by a surgeon in the effort to reduce the fracture, the lower fragment was still on the dorsum of the upper one but had been displaced laterally toward the ulnar side, quite the opposite displacement to that usually present. I attributed the unusual character of the displacement to the hand having been kept strongly flexed laterally to the ulnar side while consolidation of the fracture was taking place, while at the same time the dorsal displacement was left unreduced. The styloid process of the ulna was torn off and the scaphoid bone fractured transversely at its middle. Much disability and pain still persisted. The accident was caused by an automobile crank kick-back.

Anterior Displacement of the Lower Fragment.—In falls upon the wrist with the hand in forward flexion it would seem theoretically possible that the lower end of the radius might be torn off, even as it is in the position of extension or backward flexion, although the mechanical conditions from the anatomical configuration of the lower end of the radius are much less favorable for the production of a force of avulsion. The rarity with which a fall is sustained by the hand with the wrist in flexion is so great that the occurrence of the accident in question is much less frequent than is the fracture with the wrist in extension.

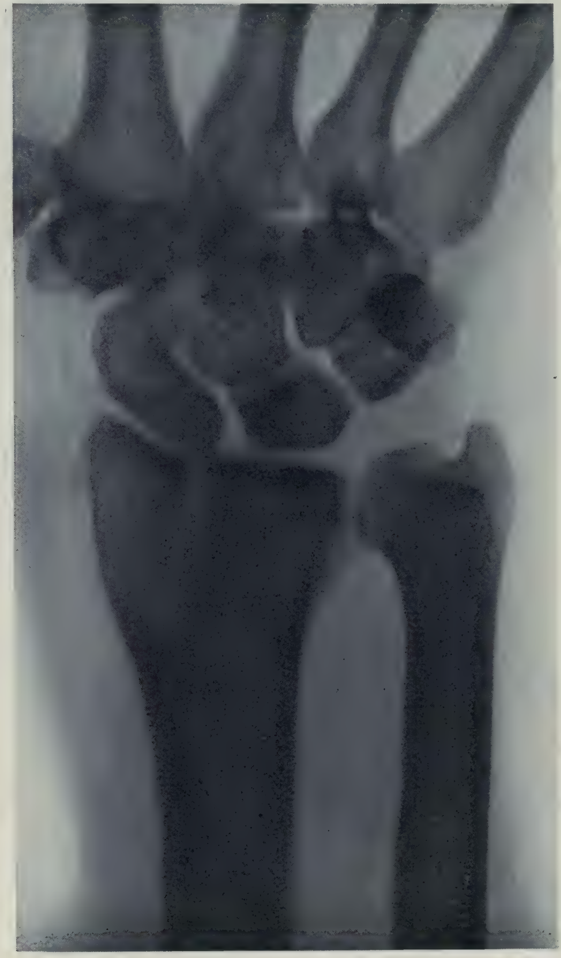


FIG. 50.—Longitudinal fracture of the base of the radius (Rankin, *Long Island Med. Jour.*, December, 1910).

As long ago as 1847, R. W. Smith, of Dublin, in his work on "Fractures in the Vicinity of Joints," p. 162, described this condition, based upon a case in which the lower end of the radius was broken and driven forward along with the carpus as the result of a violent fall upon the back of the hand. In 1896 this particular accident was made the subject of careful study by John B. Roberts, of Philadelphia, who collected a number of histories and described specimens in which the condition exists (*Transactions of Amer. Surgical Assn.*, 1896, xiv, 611).

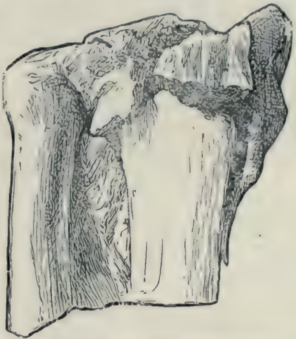


FIG. 51.—Transverse fracture with impaction of upper into lower fragment and comminution of lower fragment. The ulnar styloid is cracked off, but still held by its fibrous envelope. (Roosevelt Hosp. Mus. No. 189.)

In 1904, Dr. Francis T. Stewart, of Philadelphia, reported to the Academy of Surgery of that city the case of a man fifty years of age who had received a fracture of the lower end of the radius from the blow of a heavy weapon upon the back of the wrist. Skiagrams showed the lower fragment displaced to the palmar side. Dr. John B. Roberts at the same time described the case of a woman who had been thrown from a horse and struck on the back of her hand. The lower extremity of the radius was fractured and the lower fragment was driven forward (ANNALS OF SURGERY, 1904, xl, 423).

In 1915, Dr. J. M. Hitzrot, of New York, reported to the New York Surgical Society (ANNALS OF SURGERY, 1915, lxi, 740) a similar case. A woman was thrown from a horse and fell with her left hand flexed under her. Together with other injuries the lower ends of the radius and the ulna were fractured and the lower fragments were displaced forward and outward to the radial side. The lower projecting ends of the upper fragments could be plainly seen and palpated on the back of the wrist. Skiagraph (Fig. 100) shows the lower fragments of both radius and ulna completely displaced forward and driven upward along the palmar surface of the radius. Traction and manipulation failed to correct the position, whereupon the parts were exposed by an incision on the dorsum, when it was found that the lower end of the upper radial fragment had perforated the annular ligament by the fibres of which it was held and the whole mass of the extensor tendons had dropped between the fragments. After operative readjustment of these structures had been effected, the proper apposition of the bone ends was readily made and a final ideal repair secured.

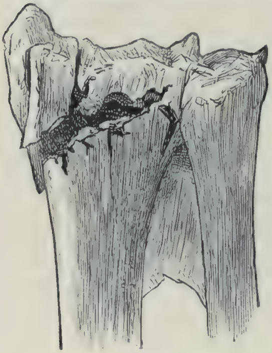


FIG. 52.—Line of fracture from upper edge of ulnar facet transversely and obliquely outward and backward. Lower fragment comminuted. For lateral view see Fig. 74. (N. Y. Hosp. Mus. No. 120.)

Among the cases which are the subject of the present study, a number have already been figured (Figs. 62–65) in which anterior displacement of some of the comminuted pieces of the fragment, riven by the descent into it of the end of the upper fragment, is present.

In Figs. 102 to 106 are presented other examples in which the articular segment is displaced forward. In the case which is the subject of Fig. 48 the anterior lip of the carpal articular surface has been split off by a longitudinal line of fission which exaggerates the normal palmar projection of that part of the radius. These cases, however, together with the similar ones already noted on page 29, belong to quite a different class from those with anterior displacement considered by Smith and Roberts, and from the case of Hitzrot shown in Fig. 100. In the latter class we have to do with a distinct forward movement *en masse* of the fragment.

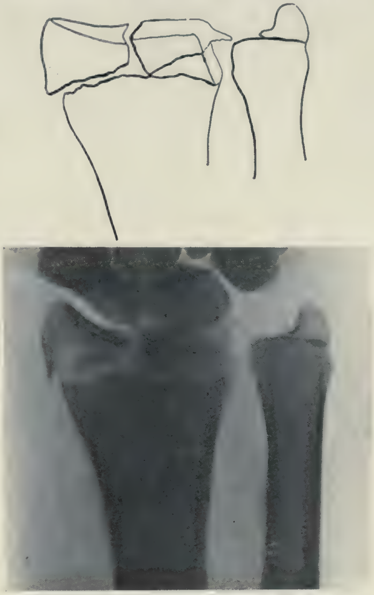


FIG. 53.—Lower fragment comminuted and displaced backwards two-thirds of its thickness as demonstrated in a lateral view. Ulnar styloid broken off.

When one considers the histories of the cases in which such anterior displacement of the lower fragment has been found, it is evident that they are the results of direct violence applied to the dorsum of the lower end of the radius rather than of any such indirect force as that which plays so large a part in the causation of the ordinary fracture occurring during extension of the wrist.

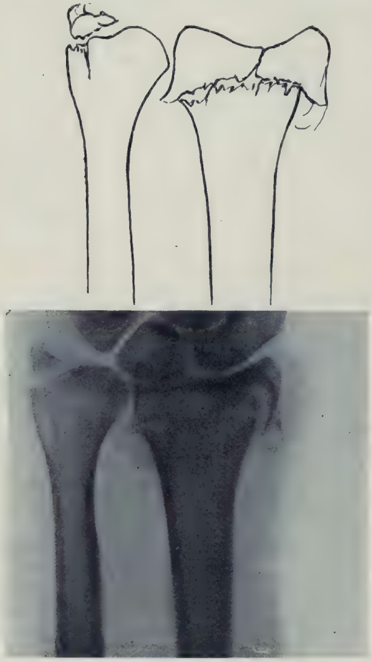


FIG. 54.—Transverse fracture three-eighths inch above carpal edge. Lower end of shaft fragment impacted into articular fragment. Ulnar styloid broken off.

In Figs. 104 to 106 the condition of the lower end of the radius speaks plainly for a blow directly upon the dorsum of the articular expansion of the bone, breaking it off and driving it forward.

This particular condition shown in Figs. 104 and 105 occurred in the person of a heavy woman, thirty years of age, who fell in alighting from a trolley car. Presumably she put out her hands to break her fall. No positive statement as to the exact manner in which the wrist came in contact with the pavement can be given by her.

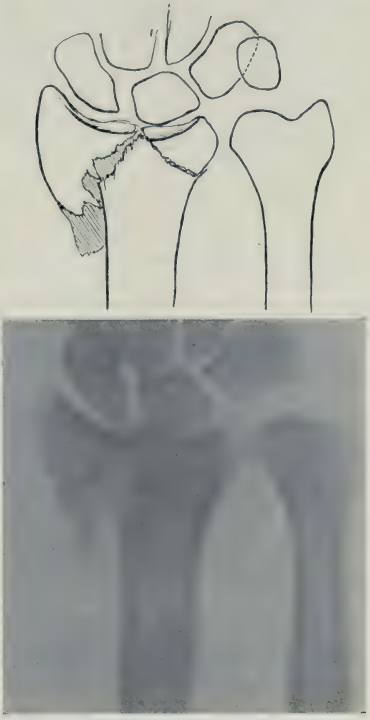


FIG. 55.—Lower end of upper fragment telescoped into lower; marked displacement outwards and backwards of the outer half of the radial articular facet and the styloid process, carrying the wrist and hand with it. Ulna torn from its radial connections.

The displacement shown in Fig. 106 is quite similar to that in Fig. 104. The obliquity of the line of fracture running upward and forward and the slight forward slide of the lower fragment speak positively for it to have been caused by a force from the dorsum. It occurred in the person of a child, seven years of age, who tripped while running over a boardwalk and fell violently forward.

Epiphysial Separations.—In children and adolescents, up to the age when the conjugate epiphysial cartilage becomes ossified—nineteenth to twentieth year—the result of a cross-breaking strain upon the lower end of the radius may be that the fragment that is torn off is composed practically of the epiphysis only (Figs. 86, 87, 107, 108, 109, 110).

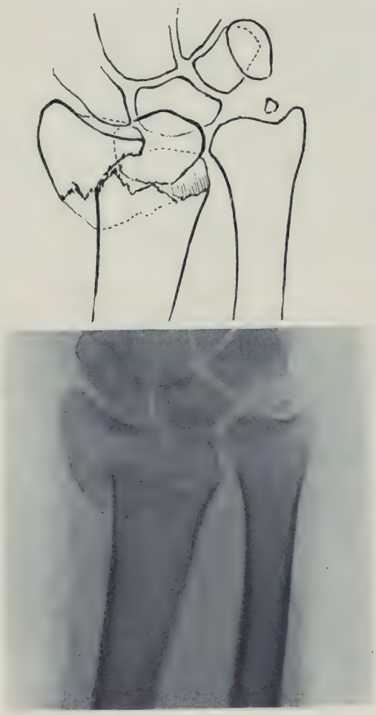


Fig. 56.—Upper fragment driven into lower fragment which is comminuted and carried backward and out. Abundant callus. Head of ulna forced down upon carpus; ulna styloid torn off.

Owing to the relatively small size of the bony nucleus of the epiphysis during early childhood the base of the radius during this period partakes of the tough and elastic characteristics of the predominating cartilage rather than of the friability and density of bone. After the age of twelve the osseous development of the epiphysis has advanced so far as to materially alter its physical nature. The cases of epiphysial separation recorded are practically limited to the years between twelve and twenty. The separation, however, seldom, if ever, occurs through the substance of the cartilage but rather through the spongy, osseous tissue which immediately adjoins it (Ollier), a certain amount of which always clings to the cartilage. Not infrequently the fracture plane, which has begun along the epiphysial line in front, passes into the substance of the diaphysis as the posterior surface of the radius

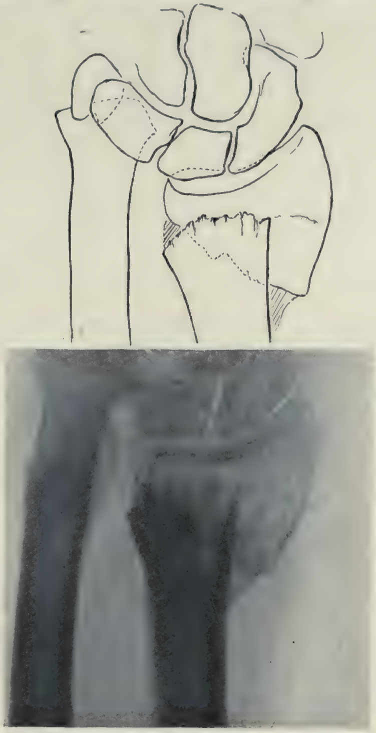


FIG. 57.—Extreme backward and outward displacement of lower fragment carrying carpus with it. Note callus filling in angle on outer side between lower and upper fragments. Upper fragment driven into lower; ulna torn away and thrust down on to the inner and posterior aspect of the carpus.

is approached by the fracture line (Fig. 110). Epiphysial separations are comparatively infrequent because the elasticity and resiliency of the osseocartilaginous tissues of childhood lessen the tendency to any fracture at the wrist, notwithstanding the frequent falls that are characteristic of the heedless activity of childhood. A child's fall, broken by the outstretched hand, more frequently eventuates in a fracture of the forearm or in a dislocation at the elbow than in a fracture through the lower end of the radius. The bone may give way through the shaft at a point but little above the epiphysial line, without any involvement of the epiphysial conjugate cartilage. Such a condition is presented in Figs. 88, 89, 99, 106.

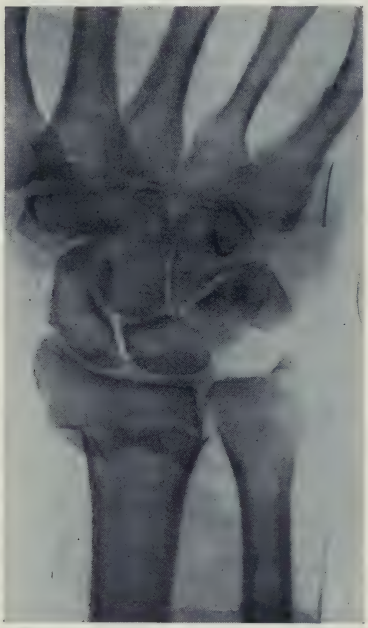


FIG. 58.—Backward and outward displacement with moderate impaction of upper fragment into lower.

Arrest of growth of the radius from premature ossification of the lower epiphysial conjugate cartilage, the result of the traumatism of a fracture, may result, but is rare. Of 100 cases of traumatic epiphysial separation of various bones, collected by von Bruns, in 13 only was growth arrested; 8 of these were of the lower epiphysis of the radius. Fig. 111 shows the condition produced by lack of development in length at base of radius after a fracture through the epiphysis sustained at the age of twelve years. The normal growth of the ulna has made its lower end to become very prominent on the ulnar side of the wrist, while the carpus, bound more strongly

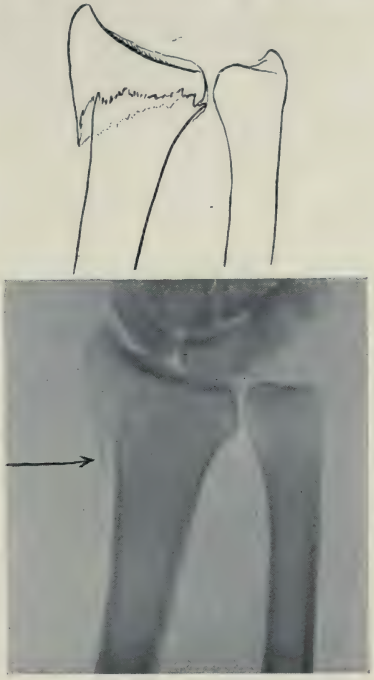


FIG. 59.—Lower end of upper fragment driven into lower fragment, most deeply on outer side; lower fragment displaced outwardly (arrow).

and extensively to the radius, is left behind pushed over to the radial side of the wrist. There is no suggestion of shortening of the radius from unreduced overlapping of the fragments of the original injury. This wrist was seen by the writer immediately after the original accident; the backward displacement of the lower fragment was very marked; it was reduced without difficulty and the subsequent course of repair was without accident. Twenty years later, the boy having become a man thirty-two years old, an opportunity occurred to examine the wrist, and the condition as shown in the figure

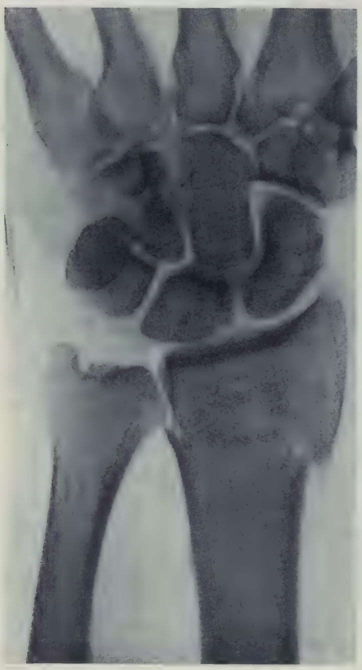


FIG. 60. — Man aged fifty-two years. Transverse fracture, three-fourths of an inch above carpal articular surface. Result of automobile crank kick-back.

was found present. A plaster cast was taken of it, from which the photograph reproduced in Fig. 111 was taken. The function of the wrist has not been impaired.

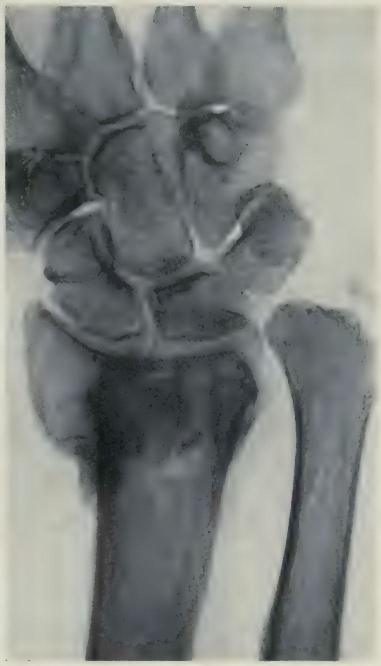


FIG. 61.—Man aged forty-five years. Transverse fracture, three-fourths of an inch above carpal articular surface, with backward and internal displacement of lower fragment which is comminuted by impaction into it of upper fragment; styloid process of ulna torn off. Head of ulna torn away from its attachment to the radius and thrust downward and outward. Fracture of scaphoid; result of a fall from a ladder. For lateral view see Fig. 96.

Poland ("Traumatic Separation of the Epiphyses," p. 564) says that there are several specimens in the museums of London hospitals which show great dwarfing of the radius and deformity of the forearm after what was probably an epiphysial separation. He reports also a number of clinical cases in which arrest of growth of radius followed such epiphysial separation. Great or complete displacement of the epiphysis, as in the case of my own patient, must usually have taken place to supply the conditions requisite for arrest of growth at the base of the radius, which is due to the premature ossification of the conjugate cartilage during the process of repair. Such premature excess of ossification occurs more especially in comminuted fractures which involve the extremity of the diaphysis as well as the epiphysis. But in some of the recorded cases of arrest of growth after epiphysial injuries there has been no displacement and in some but little local injury.

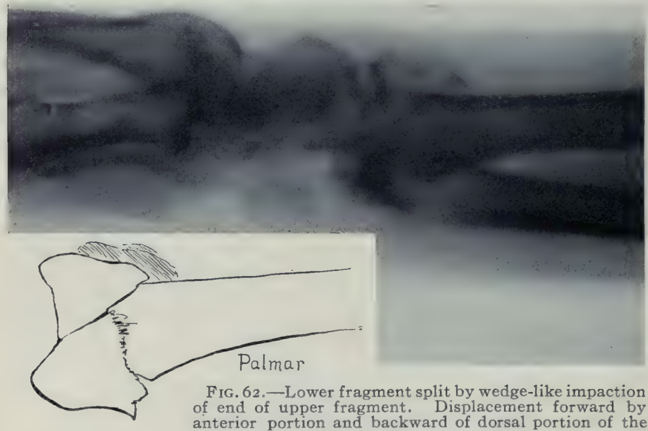


FIG. 62.—Lower fragment split by wedge-like impaction of end of upper fragment. Displacement forward by anterior portion and backward of dorsal portion of the split part. See Fig. 57.

Authors in treating of wrist injuries in childhood, and surgeons in undertaking the treatment of such cases, ought to be very explicit to state the possibilities of later deformities appearing as the result of developmental changes, over which the surgeon has no control, and for which he may in no degree be responsible or deserving of reproach.

Dorsal Untorn Periosteum.—The peculiar elements which determine the usual fracture of the radius *par arrachement* are such that as the lower fragment is torn away from the rest of the bone and slips backwards, it tends to strip up from the adjacent dorsal surface of the shaft of the radius more or less of the dense, loosely adherent periosteum which enwraps this part of the bone. The dorsal periosteum further is so closely blended with the fibrous tissue of the

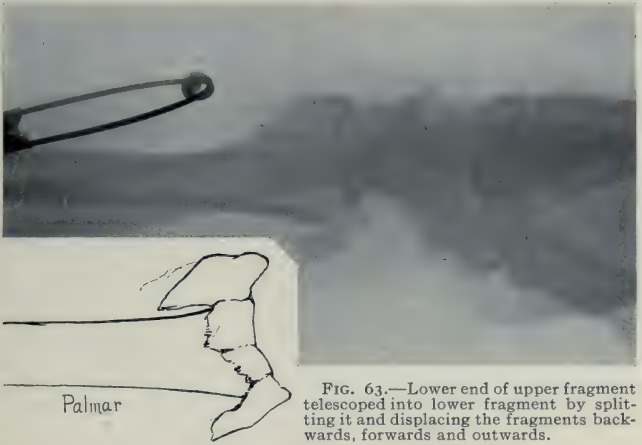


FIG. 63.—Lower end of upper fragment telescoped into lower fragment by splitting it and displacing the fragments backwards, forwards and outwards.

tendon sheaths which lie over it that the combined mass constitutes a thick strong fibrous envelope to the parts enclosed within it. This has been repeatedly referred to in previous paragraphs and is well shown in many of the figures already presented to illustrate other phases of this injury—see especially Figs. 32, 33, 34, 70, 73, 74, 90, 94, 97.

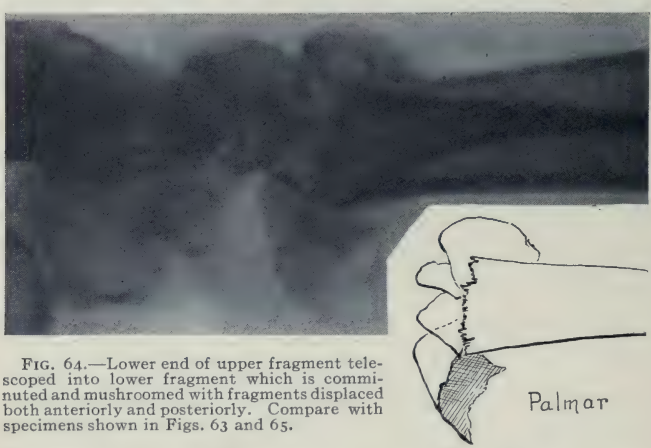


FIG. 64.—Lower end of upper fragment telescoped into lower fragment which is comminuted and mushroomed with fragments displaced both anteriorly and posteriorly. Compare with specimens shown in Figs. 63 and 65.

This untorn portion of the dorsal periosteum becomes a sort of ligament which continues to connect the two fragments and exercises some control over their relations to each other, and also remains as a determining factor in the extent and position of the callus which is formed to weld them together again.

As soon as the extending force is withdrawn and the hand again falls into forward flexion, this pseudo-ligament is made tense (see Fig. 34) and in its tension binds in its faulty position the lower fragment in whatever degree of entanglement with or impalement upon the lower end of the upper fragment it may have sustained. This effect is well shown in Figs. 70 and 90. This band forms a real obstacle of some importance to the disentanglement of the fragments or to the breaking up of any impaction if it exists. To break up such impaction or to disentangle an overriding fragment is necessarily the first step to be taken in any effort of reduction. The appreciation of the presence and effect of this band gives an important hint as to the first manipulative step to resort to when reduction is undertaken. To facilitate the drawing apart of the broken surfaces this band must be relaxed. Such desired relaxation is at once secured by putting the hand again in full dorsal flexion (Fig. 32).

As long as the return of the lower fragment to its normal relation with the upper fragment is imperfect a space is left between the stripped up periosteum and the compact layer of the denuded bone. This space fills with blood-clot to be later replaced by callus which solidifies duly into bone. The amount of this new-formed

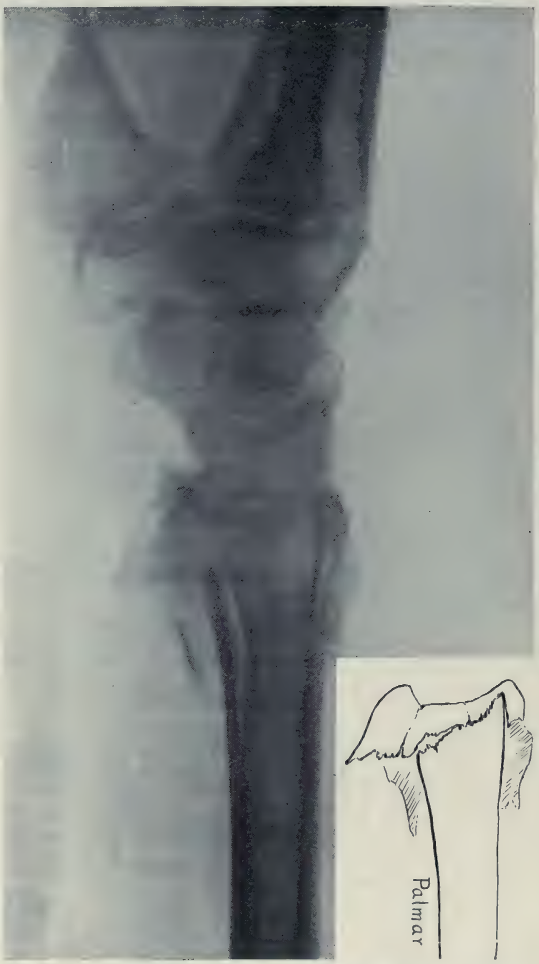


Fig. 65.—Upper fragment telescoped into lower; lower fragment split into many pieces, with anterior displacement of a portion.

bone and its contour is quite accurately outlined by the periosteum that contains it. This formation of new bone underneath the periosteal bridge did not escape the notice of earlier writers on this fracture, although misinterpreted by some as an evidence of impaction. Figs. 112 to 115 are the familiar illustrations from Robert William Smith's "Treatise on Fractures in the Vicinity of Joints," Dublin, 1847. They show sagittal sections of old fractures of the lower extremity of the radius healed in deformity. It is to be noted that the defect left on the palmar side by the backward slipping of the lower fragment, where the periosteum was torn cleanly across, has not been filled up, but the end of the upper fragment continues to project sharply—see especially Figs. 114 and 115. Posteriorly,

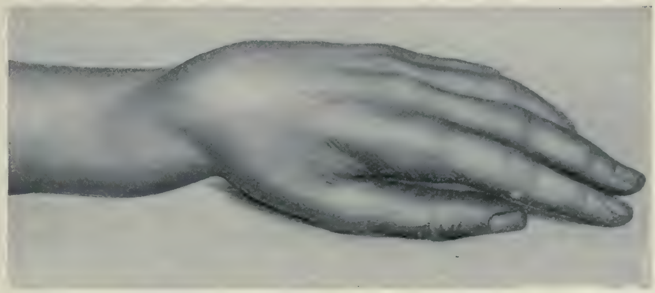


FIG. 66.—Deformity of wrist due to fracture of the base of the radius with moderate backward displacement of the lower fragment.

however, where the periosteum has been stripped up as described, abundant new bone has been laid down, reaching some distance upwards along the dorsum of the radius and enclosing deeply the cancellated cylinder that is here present.

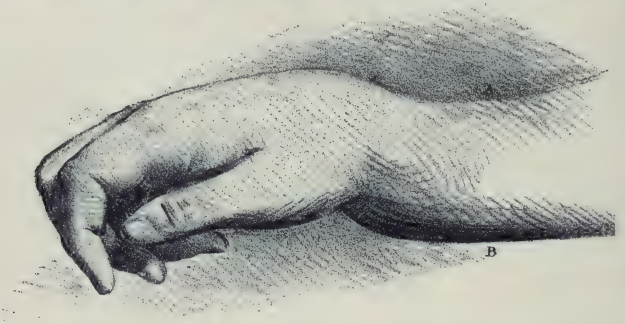


FIG. 67.—Typical silver-fork deformity caused by fracture of lower extremity of the radius, with moderate backward displacement of the lower fragment.

Figs. 98 and 99 show the result of the same source of new bone formation.

Incomplete Fractures.—That the lower end of the radius is frequently torn off but partially on account of the feebleness of the avulsive force, or because of there being in the particular bone an unusual degree of strength to resist such force, is to be expected if we are correct in the description of the mechanism whereby the more serious injuries are produced.

The longitudinal splits and the radiating fissures of the articular facet of the base of the radius (Figs. 36, 43, 48, 49, 50) are included in this class, and also those many cases in which the lower fragment is torn off, but not displaced backward, being still held by the periosteal hinge on the dorsum (Figs. 116, 117, 118). This is ideally shown in the experimental fracture shown in Fig. 10. It is the condition in the specimens from which skiagraphs 12, 13, 29, 31, and 74 have been taken. When the force of extension is suspended in such cases the fragments spontaneously resume their proper relations to each other and no deformity follows. Under rest repair rapidly takes place. The injury is classed simply as a sprained wrist unless a skiagram is taken and the real lesion demonstrated.

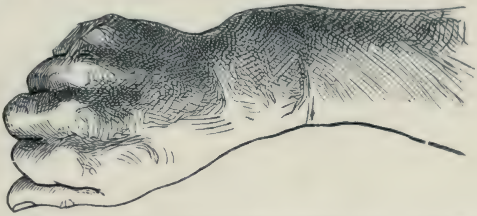


FIG. 68.—Showing bend of wrist to radial side, projection of ulna; external appearance of the wrist from which the specimen shown in Fig. 25 was obtained.

Fracture of the Ulnar Styloid Process.—Reference to many of the preceding illustrations (Figs. 13, 25, 28, 48, 49, 53, 54, 56, 61, 71, 96, 100, 105), which present skiagrams of recent fractures, shows in each that the styloid process of the ulna has been torn off, in addition to the injury to the radius. This injury to the ulna is a very frequent one, and is almost inevitable when there has been much backward displacement and rotation outwards of the articular fragment of the radius. The mechanism of its production has been described on page 33. The carpo-ulnar fibres, of the anterior common ligament (Fig. 3*b*) sustain most of the cross-breaking strain after the articular base of the radius has given way, and the tendency is to tear off the styloid process into which these fibres are inserted, a result which in fact frequently follows. In extreme degrees of violence the jagged end of the broken ulna may be forced through the skin. The student of the literature of fractures

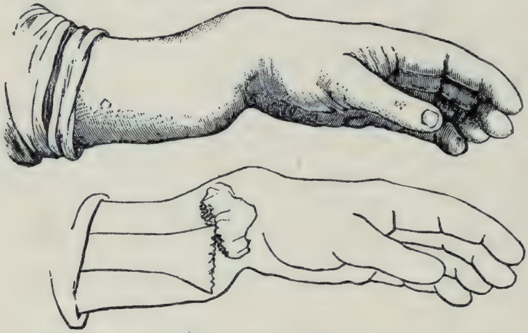


Fig. 69.—Diagram from Levis to show relations of bony displacement to external deformity.

will remember the laconic but comprehensive account given by Sir Astley Cooper, in his "Treatise on Dislocations and Fractures of the Joints" (7th ed., p. 378), of such a case, under date of June 21, 1818: "John Winter fell from a ladder on his hand and knee; the hand was bent back, and the ulna protruded at the inner part of the wrist. Mr. Steel, of Berkhampstead, attended; the bone was reduced, a roller was put around the wrist, and the wound healed very soon by adhesion."

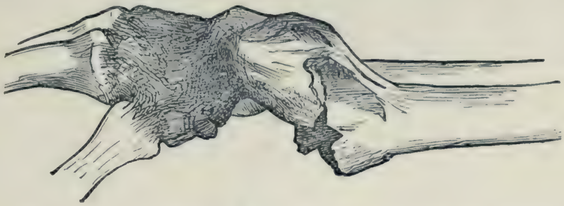


FIG. 70.—Note posterior displacement of lower fragment without impaction; stripped up periosteum still forms a band uniting the upper and lower fragments and holding them in their new relations.

Associated Fracture of the Carpal Bones.—That the carpal bones are not frequently fractured or dislocated as the result of violence sustained by the wrist is due not only to the protection which they receive from the dense and strong fibrous ligamentous and tendinous structures by which they are invested (see Figs. 1, 3, 5), aided by the tonicity of the muscular masses by which these tendons are controlled, but also

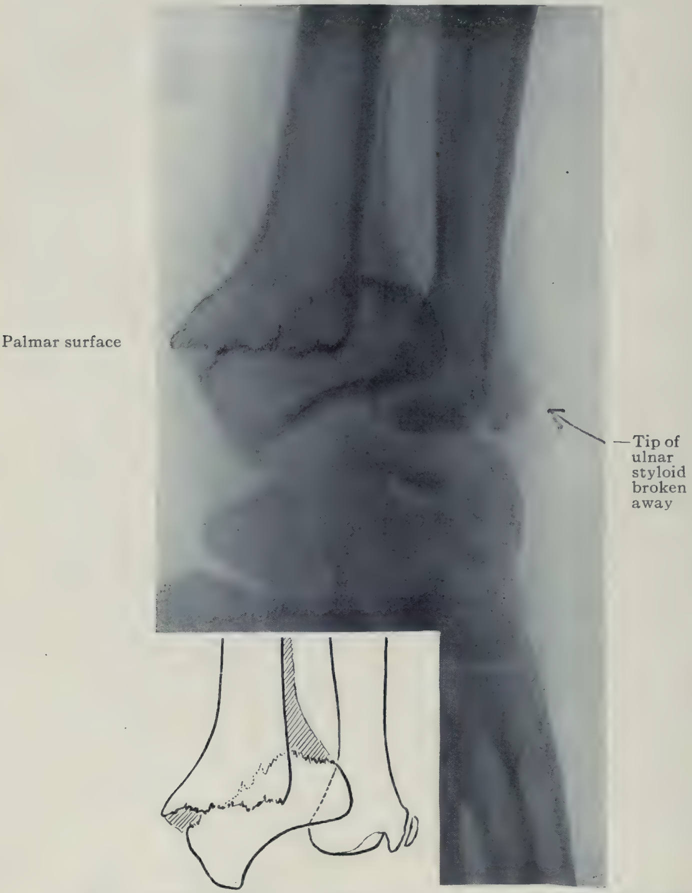


FIG. 71.—Typical fracture by avulsion of the lower end of the radius with moderate degree of backward displacement of the lower fragment and slight impaction of upper into lower fragment; tip of styloid process of ulna torn off. Note angle on posterior aspect filled up with callus. Note sharp projection of the anterior edge of the upper fragment which irritated and disabled the palmar flexors.

by the powerful manner in which the most frequent forces of extreme flexion backwards or forwards are transmitted upwards to the base of the radius. In this connection those injuries are not considered which are caused by direct force, as a blow or a crush. As, however, one considers the strength of the disruptive force which the scaphoid and semilunar bones especially must sustain in the course of such traumatism as is present in a forced hyperextension, one is sure that in occasional instances these bones of the carpus will be fractured or forced out of their position at the same time that the radius is fractured, and that in some instances the chief lesion will be sustained by them—the greater the force and the more resistant the lower end of the radius the more positive the effect upon the adjacent bones of the carpus. Thirty-five years ago I had the opportunity of dissecting the wrist shown in Fig. 25 which had been injured by a fall from a height of 20 feet to the ground. The sketch was made at the time the dissection was done. In this wrist I found that not only had the styloid processes of the radius and of the ulna been torn away but that the semilunar bone had been fractured transversely, as shown in the drawing. Similar injuries both of the semilunar and of the scaphoid were occasionally detected by me in the course of many experiments made on the cadaver as to the results of overextension of the wrist when associated with force applied from above and transmitted through the bones of the forearm to the wrist.

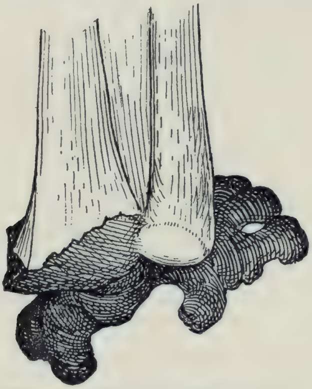


FIG. 72.—Showing relations of elements of wrist-joint following backward displacement of torn-off fragment of radius; hand in position of forced dorsal flexion.

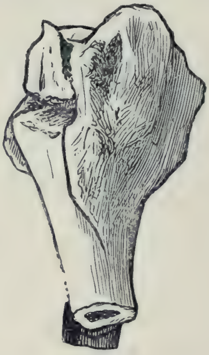


FIG. 73. — Demonstrates well the intact state of the posterior periosteum and fasciæ which is stripped up from the back of the shaft for an inch with backward tilting of the lower fragments.

In 1905 Codman and Amory (ANNALS OF SURGERY, xli, 321) published their elaborate study on "Fracture of the Carpal Scaphoid and Dislocation of the Semilunar Bone." A large proportion of the cases reported by them were the result of the same kind of traumatism as that which is the usual cause of fractures of the base of the radius, and some of them were associated with recognized fractures of the radius. Among our own cases, in the one from which the skiagraph shown in Fig. 119 was made, a fracture of the scaphoid can be clearly discerned. The fractured scaphoid shown in Fig. 120 and the dislocated semilunar shown in Fig. 121 were both produced by the hyperextension of a wrist caused by a kick-back of an automobile crank and singularly enough in the same individual at different times; the scaphoid of the right carpus having been first broken and, three months later, as the result of the same kind of force, the left hand being now used, the semilunar bone of

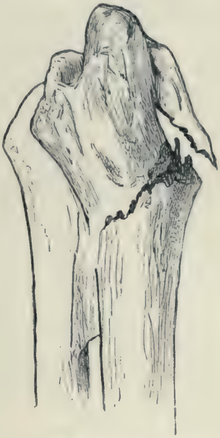


FIG. 74.—Transverse fracture (see Fig. 52) with fragments separated in front, but held together behind by periosteum, resulting in backward tilting of the lower fragment. (N. Y. Hosp. Mus. No. 120.)

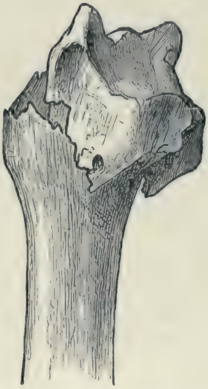


FIG. 75.—Complete detachment of lower fragment with marked backward displacement and tilting. Lower fragment entangled upon serrated posterior edge of upper fragment. (N. Y. Hosp. Mus. No. 123.)

the left carpus was squeezed out of its place as shown in the figure. The radius escaped injury in both instances. Continued tenderness and prolonged disability in a wrist following a fracture of the base of the radius, after repair of the bone has taken place, should awaken suspicion as to the presence of coincident injury to the carpus, and call for careful examination as to its presence.

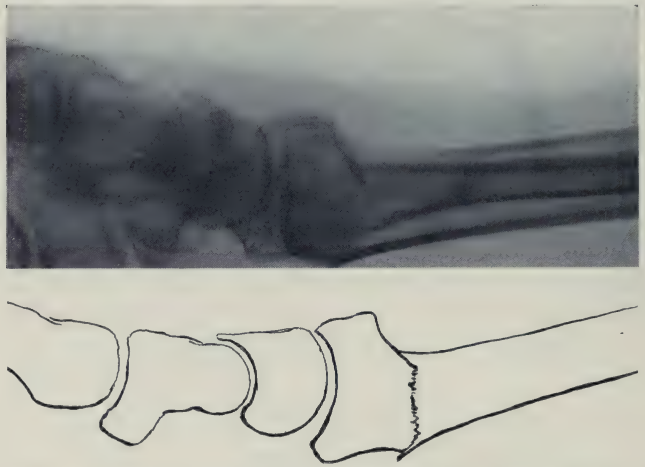


Fig. 76.—Transverse fracture of lower extremity of radius, backward displacement of the lower fragment, with impaction.

Associated Injuries to the Periarticular Structures and Diastasis of the Ulna.—When the lower fragment of the radius comprises the whole width of the bone and is carried backward to any degree (Fig. 97) the ligaments that bind it to the head of the ulna now sustain the greater part of the residual strain; and, as a result, first, the hand, carpus and lower fragment rotate in a backward direction around it, as already described on page 33, the contour of the wrist is altered; the radial fragment, thrown into supination, projects on the outer side of the dorsum and the head of the ulna appears more prominent on the inner anterior aspect of the wrist (see Figs. 66 and 68). If the force has become expended at this point, the radio-ulnar ligaments still hold, and no diastasis of the head of the ulna from the radius occurs. In the skiagraphs which have already been pre-

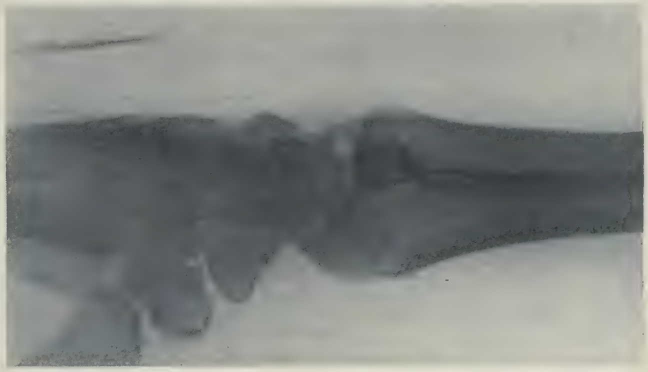


FIG. 77.—Lower fragment torn from upper in front but still attached behind by periosteum. Callus fills up the angle of separation in front. Note the alteration in the contour of the base of the radius and the changed plane of the carpal articular surface.

sented examination shows no separation of the head of the ulna in a large proportion of them (see Figs. 11, 12, 14, 15, 17, 51, 52, 58, 59, 60, 99, 107, 108, 109). Not infrequently, however, especially when the fall has been from a height or with much violence, the radio-ulnar ligaments are ruptured and the head of the ulna, torn from its radial connections, is driven inwards, forwards and downwards in varying degrees according to the degree of violence inflicted. In some instances, as illustrated in Figs. 53 and 55, the ulna, after being torn loose, is merely forced away from the radius, broadening the wrist and projecting on the ulnar side. Figure 119 shows a greater degree of displacement downwards of

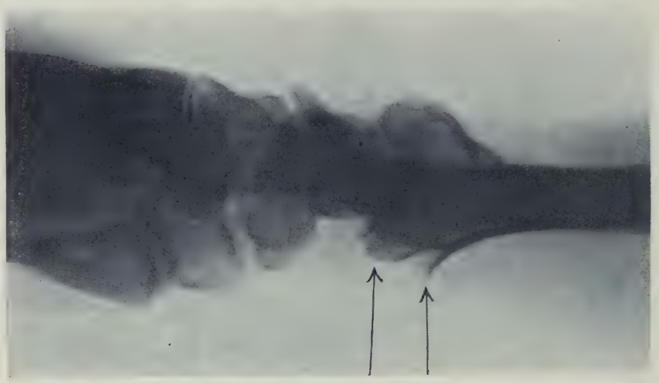


FIG. 78.—Line of separation anteriorly indicated by arrows; lower fragment displaced backwards and canted over and entangled upon posterior edge of upper fragment—slight impaction. Note mass of callus filling up angle behind.

the head of the ulna. Compare also Figures 13, 16, 54, 56, 105, 110. Still greater degrees of displacement, some of them very extreme, are presented in Figures 57, 60, 61, 71, 92, 93, 94, 95 and 96. It is in this last class of cases that occasionally the ulna is thrust through the skin. The external deformity produced in these cases of extreme displacement is very marked (see Fig. 122).

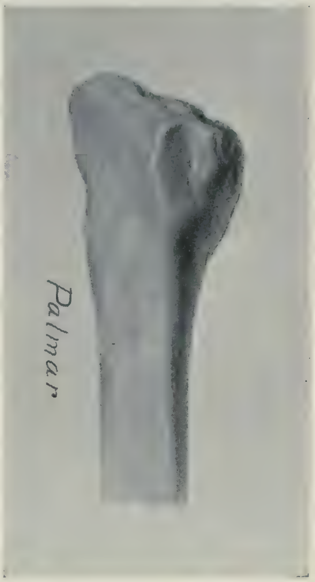


FIG. 79.—Loss of anterior projection of palmar lip of articular surface of base of radius, result of fracture. (See Figs. 80 and 81.)

It is a misnomer to speak of these conditions as dislocations of the ulna. It is not the ulna that is dislocated or torn away from its attachments to the radius; it is the torn-off fragment of the radius, carrying with it the carpus and the hand, that is dislocated and separated in varying degrees from its relations to the ulna. The injuries that are sustained by all the soft tissues about the wrist-joint, coincident with

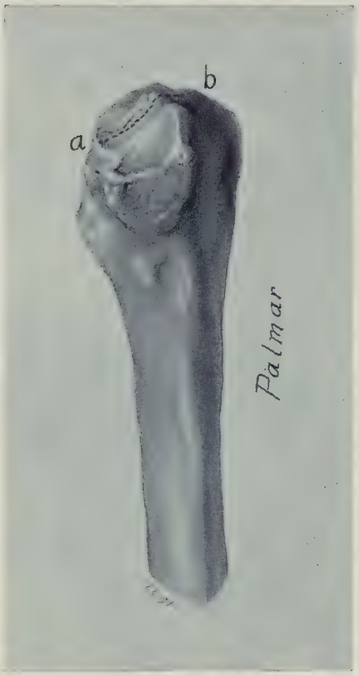


FIG. 80.—Old healed fracture of the base of the radius in which there has been backward bending of the lower fragment without displacement of the posterior bony lamellæ; the plane of the articular facet is changed (see Fig. 116); the lower palmar surface is flattened by the loss of the projection normal to the anterior articular lip (Fig. 115). The changed contour is suggestive of an original break similar to that shown in Fig. 71, *q.v.* Specimen obtained from a dissecting-room cadaver.

the bone lesions that have been described, are extensive and important. Ligaments are violently stretched and partially lacerated even in the minor degrees of injury; sometimes they are entirely ruptured; the synovial sacs of the articulations are badly contused and sometimes lacerated and filled with blood; the sheaths of the tendons, both in front and behind, are injured; in front the projection of the ragged edge of the upper fragment into the midst of the flexor tendons may lacerate their sheaths and irritate the tendons, while behind the strip-

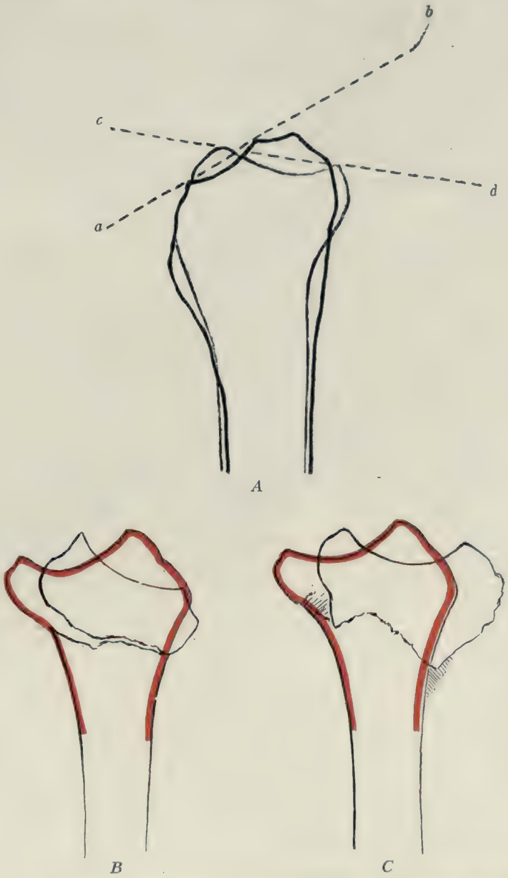


FIG. 81.—Outlines of the lower ends of fractured radii constructed from the specimens shown in Fig. 80 (*A*), Fig. 77 (*B*) and Fig. 78 (*C*). On these are superimposed outlines in red showing the normal contour of the base of the radius (see Fig. 1). In *A*, the dotted line *ab* indicates the plane of the articular surface of the injured bone; the line *cd*, that of the normal bone. The change in the plane of the carpal articular surface of the radius even in minor degrees of displacement is unmistakable.

ping of the periosteum and its later continued tension involves in its results the extensor tendon-sheaths with the floor of which it is intimately blended.

Effusions of blood and lymph into the anterior tendon-sheaths and adjacent connective-tissue spaces quickly produce a well-marked swelling on the front of the wrist above the annular ligament which exaggerates the deformity formed by the bone displacement and may simulate displacement when it has been rectified. On the back of the carpus some swelling of similar character also forms, as a rule. These effusions are firm, are slowly absorbed, especially in the feeble and aged, and tend to provoke adhesions along the course of the tendons which they envelop.

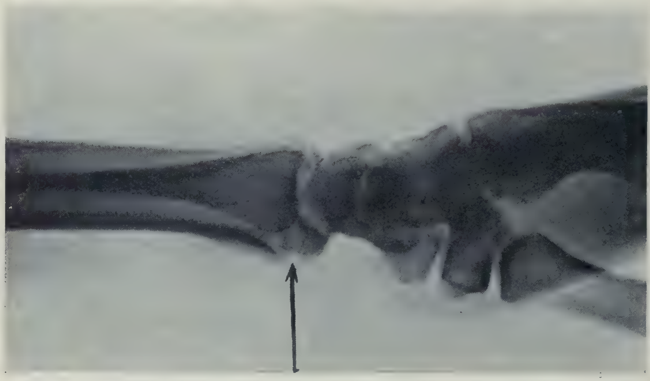


FIG. 82.—Incomplete fracture. Arrow-head points to line of fracture. Note the change from the normal of the plane of the carpal articular surface. Deformity negligible.

Permanent Alteration in Contour of the Base of the Radius.—In a considerable proportion of the cases of fracture of the base of the radius in which appreciable displacement of the lower fragment has taken place some actual permanent alteration in the form of the fragment has been produced so that perfect restitution of the normal contour of the part is impossible by any treatment and some permanent deformity is unavoidable. Some of the cancelli of the lower fragment are crushed and condensed, and in some cases more or less absorption of osseous tissue later takes place, so the bone is permanently shortened and the form of its lower extremity is changed. Such

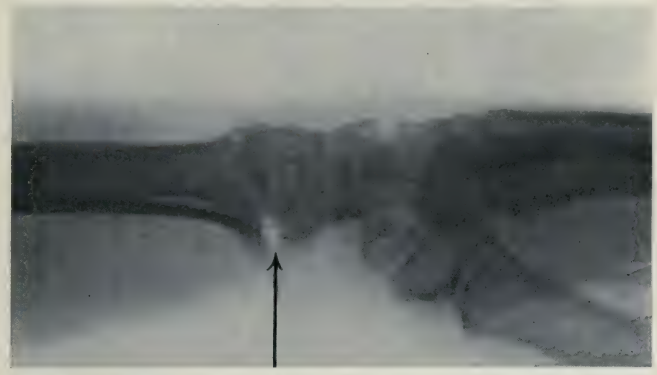


FIG. 83.—Fragments separated in front (arrow); moderate impaction of upper into lower fragment behind; no marked posterior displacement; plane of carpal articular surface changed.

changes in the bone contour are the unavoidable result of the accident itself; they cannot be prevented by treatment, nor can their presence reflect in any unfavorable manner on the treatment given. The possibility of arrest of growth of the radius following epiphysial displacements has already been discussed (page 45). In its least degree this change in the form of the base of the radius is well shown in the radius depicted in Fig. 76 (see also Figs. 101, 102 and 103). A higher degree of damage is seen in Figs. 51 to 56, 58, 59 and 61. A most marked change is in those fractures in which the lower fragment is virtually telescoped by the lower end of the upper fragment and its commi-

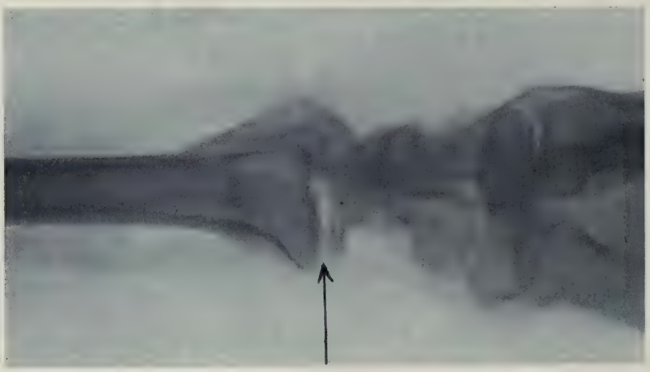


FIG. 84.—Anterior projection of radial articular lip preserved; line of fracture begins in the anterior edge of the articular lip and at a point half way to the back runs abruptly upward, splitting away a mass from the posterior lip of the radius. This fragment is comminuted.

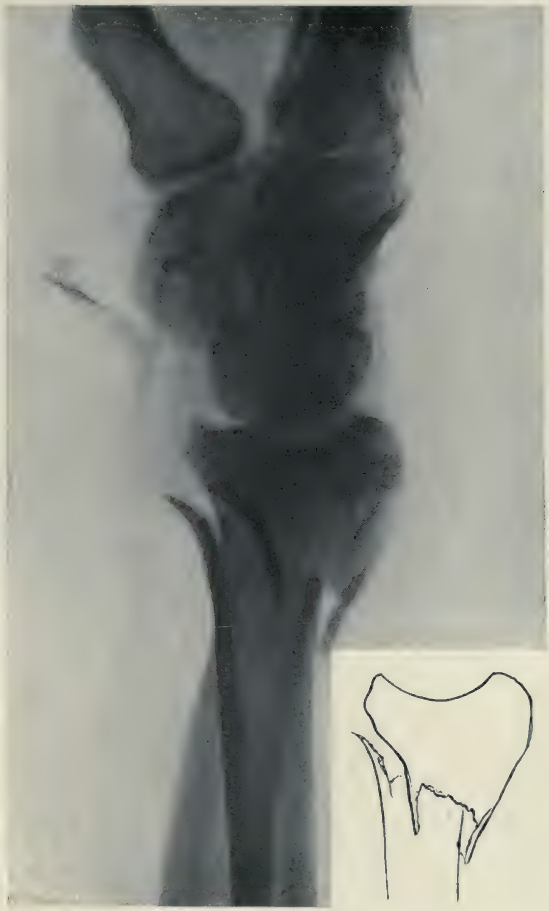


FIG. 85.—Lower fragment displaced backwards with impaction into its substance of the lower end of the upper fragment. Note particularly the sliver of bone which suggests the tearing up of the posterior periosteum which covers it. Note the sharp line of separation anteriorly.

nuted fragments driven explosively in various directions (see Figs. 62, 63, 64, 65). In the more extreme cases in which the lower fragment is carried at once so far backwards as to clear the upper fragment and ride upon its dorsum (see Figs. 57, 72, 89, 90, 91, 92, 93, 95, 99, 114, 115) such injury to the bony structure of the lower fragment is escaped, and if the lower fragment is completely replaced a fair restitution of the normal contour of the bone is obtained. It is by the failure to fully disentangle this lower fragment and bring it down fully into its proper place that the most marked deformities are perpetuated. If the backward dis-

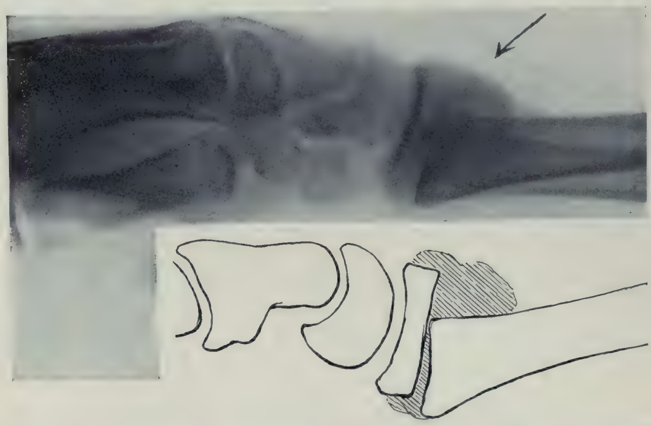


FIG. 86.—Epiphysial separation in a thirteen-year-old child; backward displacement of lower fragment; periosteum torn up and angle beneath periosteum filled with callus. See Fig. 110.

placement is allowed to remain in any degree, the vacant subperiosteal angle (Figs. 32, 34, 70, 71, 86, 87, 90, 94, 96, 97, 98, 99 and 112–115) left will in time be filled in with new bone, which will enclose the compact lamina of the lower end of the upper fragment to the point where its periosteum had been stripped from it. Any shortening of the radius will make prominent the head of the ulna as the carpus and hand fall to the radial side. In point of actual observation the projection of the end of the ulna on the inner anterior aspect of the wrist is the most noticeable and frequent permanent

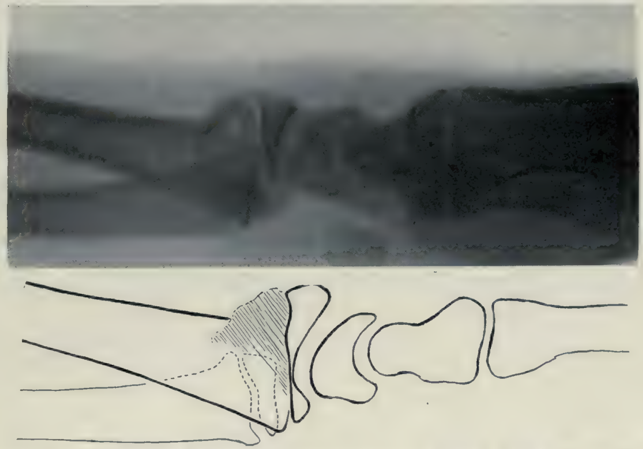


Fig. 87.—Epiphysis displaced backwards; angle on dorsum filled with callus. (Lateral view, see Fig. 107 for anteroposterior view.)

sequel of this fracture. This projection of the ulna is shown in varying degrees in Figures 68, 111 and 122. The alteration in the plane of the carpal articular facet of the radius, so often remaining, has been already fully discussed in

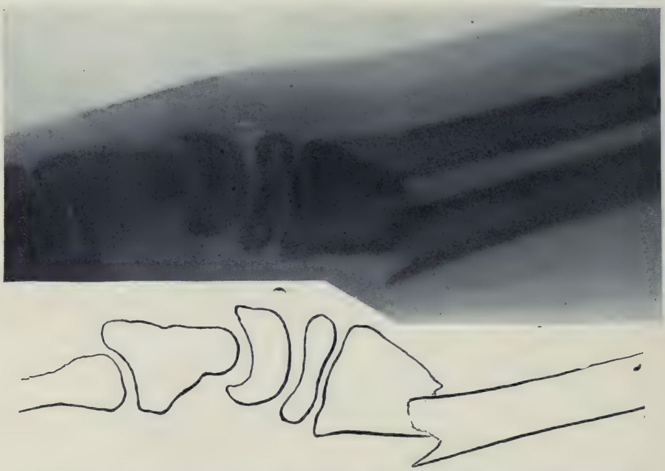


Fig. 88.—Fracture of radius seven-eighths of an inch above carpal articular surface (typical "Colles's fracture"). Lower fragment displaced backward and entangled on lower end of upper fragment.

another connection. A further word should be said as to the cause and significance of the persistent protrusion of the head of the ulna. It has already been stated that when the radius has given way the tendency is for the whole hand and the carpus to be carried backward and outward, as in supination, with the broken off fragment of the radius, as it rotates around the head of the ulna. As a result of this movement the back of the radius becomes approximated to the styloid process of the ulna and the head of the ulna is made to project notably upon the front and inside of the wrist, where it is firmly held as long as any backward displacement of the lower radial fragment remains unreduced, or the radius is shortened in its vertical length.

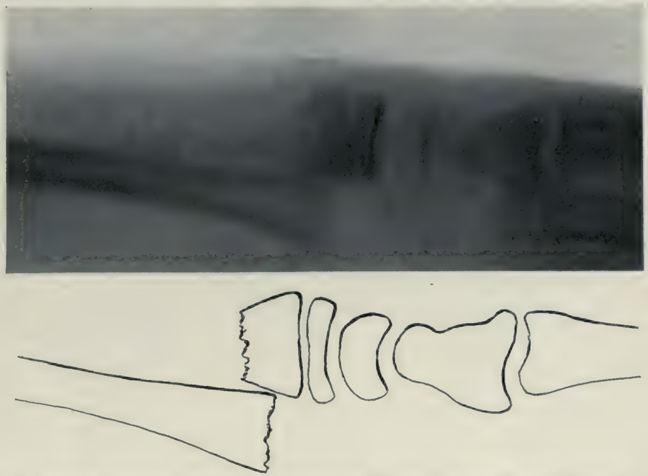


FIG. 89.—Extreme backward displacement of lower fragment, overriding the dorsum of lower end of upper fragment. Lateral of Fig. 97.

The exact cause of this movement and this locking I have made a subject of frequent experiment. It occurs in experiments on the dead body equally as well marked as in the living body; it is, therefore, not the result of muscular action. Removing integument, annular ligament and superjacent tendons, no change results; entanglement of the styloid process in the annular ligament, therefore, is not necessary for its production. If the greater part of the anterior carpo-ulnar fibres are cut away, no relaxation results. If the triangular fibrocartilage be now exposed, though this be without tension and thoroughly relaxed, the ulna and wrist are still firmly bound in their new relations to each other.

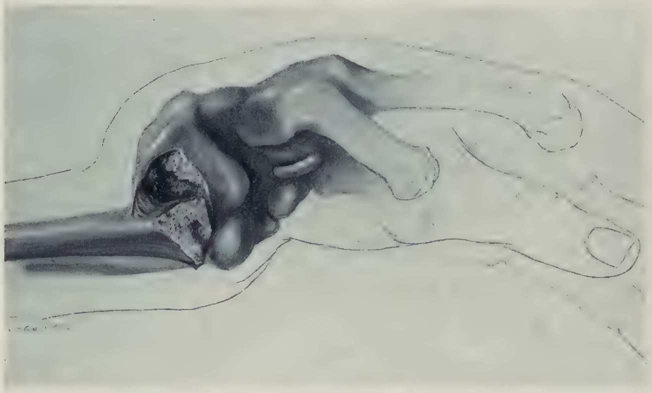


FIG. 90.—The broken-off lower fragment of the radius has been carried so far back that it lies entirely posterior to the upper fragment, the lower end of which it overrides (experimental fracture).

The real cause of these phenomena is now revealed to be the strong fasciculus of the common anterior ligament of the wrist which passes obliquely upwards to the ulnar side to be inserted into the anterior border of the styloid process of the ulna. This fasciculus has already been mentioned as the medium through which this styloid process is so frequently broken off. The obliquity of its direction and the extent and place of its insertion govern the movements which the movable parts attached to it may make. As long as the carpus and the attached fragment of the radius are in backward displacement, this fasciculus is kept tense and all rotation is prevented.

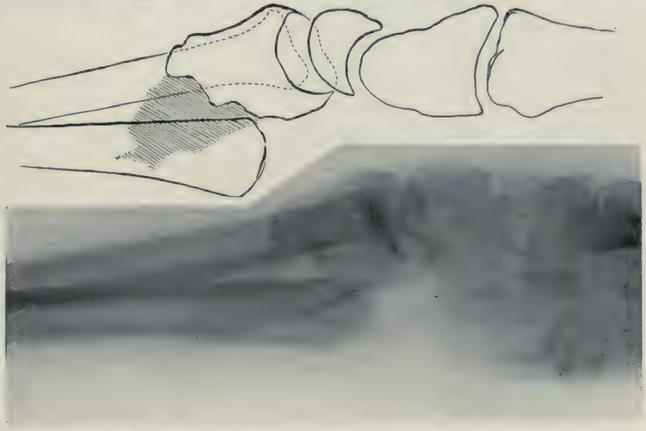


FIG. 91.—Extreme posterior displacement of lower fragment of radius, carrying with it the ulna and carpus. Lower end of upper fragment projects strongly in front. Lateral of Fig. 92.

Prominence of the head of the ulna with widening of the wrist and loss of the anterior projection of the articular lip of the radius and the imposition of a more or less backward inclination upon the plane of the carpal articular surface of the radius are therefore the most common permanent alterations in the anatomical configuration of the wrist as the result of a fracture of the base of the radius. The result of these anatomical changes is to perpet-

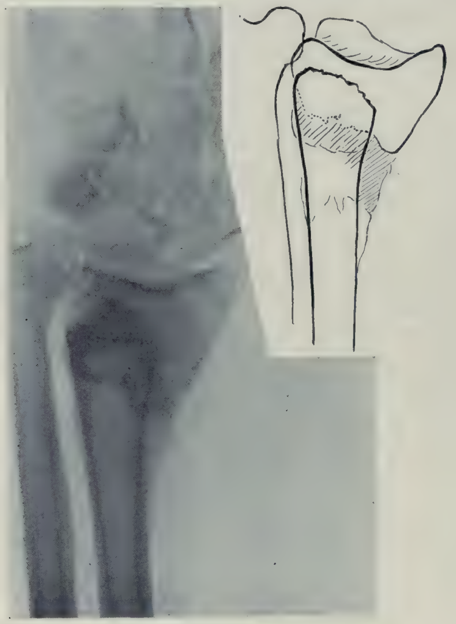


FIG. 92.—Complete displacement backwards and outwards of lower fragment produced by playing hand ball six weeks after primary injury, in a youth of seventeen years. For lateral view, see Fig. 91.

uate in some degree in many cases the deformity which immediately followed the accident. The inward and forward projection of the lower end of the ulna may persist even when there is no appreciable deformity of the radius, through lack of full restoration of the close ligamentous bands that before the injury tied it to the radius. The bony deformity, even when marked, as a rule entails of itself but slight if any functional disability; the chief sources of disability following this injury are the consequence of the periarticular changes, such as the matting of tendons and the contracture of the ligaments and the formation of fibrous bands and

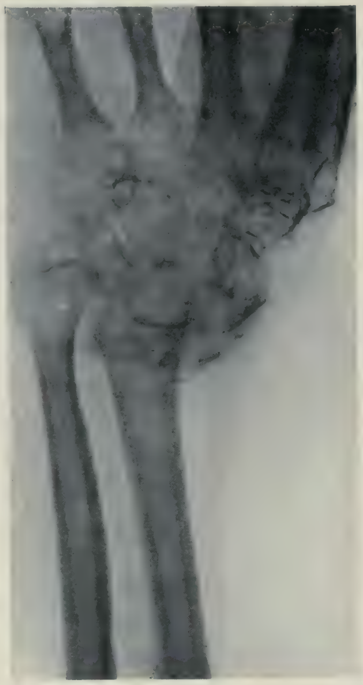


FIG. 93.—Extreme backward and outward displacement of lower fragment carrying carpus and hand. Ulna torn from its radial attachments and its head thrust down on the inner side of carpus. For lateral view, see Fig. 95. Old injury.

adhesions due to the laceration and irritations of these structures consequent upon the bony injury and displacement. Too prolonged immobilization and the undue pressure of retention splints too forcibly secured may aggravate the amount of disability referable to the injury itself.

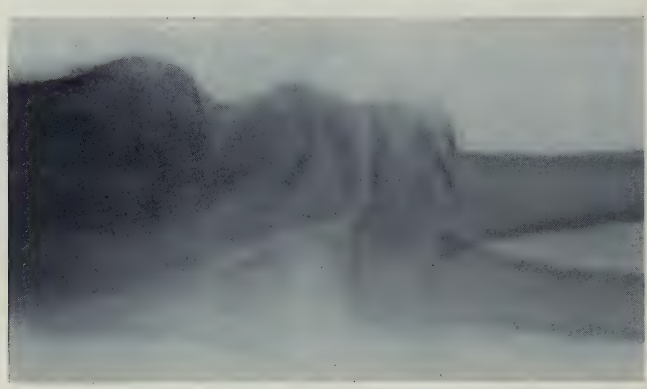


FIG. 94.—Marked backward displacement of lower fragment; entanglement without impaction of lower on upper fragment. Note untorn periosteal bands.

The diagnosis in many cases is self declared the moment the wrist is seen, so characteristic and plainly marked is the deformity (Figs. 66–69). The other cardinal signs of fracture, crepitus and abnormal mobility are often obscured, even prevented, by the amount of displacement and impaction and the resistance of untorn fibrous connecting bands, all of which conditions have been considered in preceding pages.

In cases in which the degree of displacement, and consequently the extent of deformity, is but slight, careful palpation will usually enable the surgeon to recognize the loss of the projection formed by the anterior lip of the sound bone and some abnormal elevation of the lower fragment on the back of the wrist. In the absence of any appreciable displacement the lesion of the bone may still be inferred if pressure elicits a point of special tenderness on the outside of the radius near the base of the styloid process, since such tenderness at that point could not result from any ligamentous rupture. Forward displacement of the head of the ulna is recognized at once on inspection of the wrist and when present indicates the coexistence of

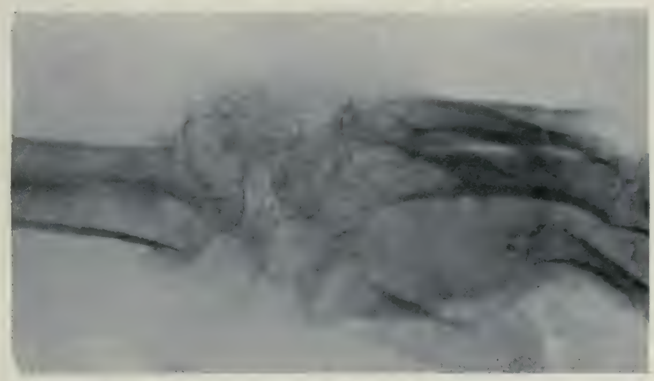


FIG. 95.—Extreme posterior displacement; skiagraph taken many years after the injury. Lateral of Fig. 93.

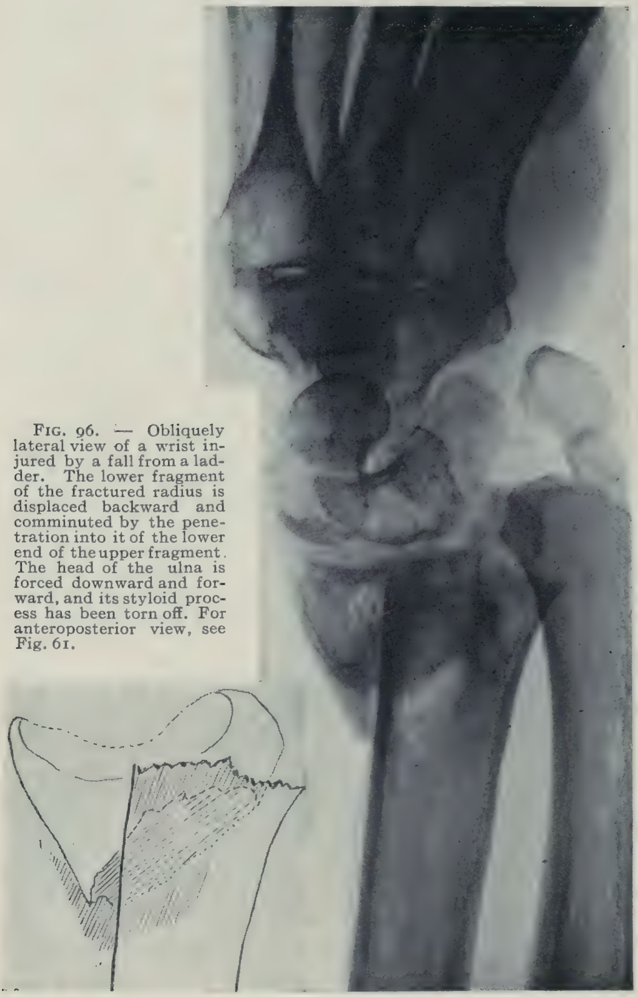


FIG. 96. — Obliquely lateral view of a wrist injured by a fall from a ladder. The lower fragment of the fractured radius is displaced backward and comminuted by the penetration into it of the lower end of the upper fragment. The head of the ulna is forced downward and forward, and its styloid process has been torn off. For anteroposterior view, see Fig. 61.

fracture of the radius; fracture of the styloid process is indicated by special tenderness at its base; manipulation may elicit undue mobility and crepitus, but it is rarely so completely torn away as to become notably displaced.

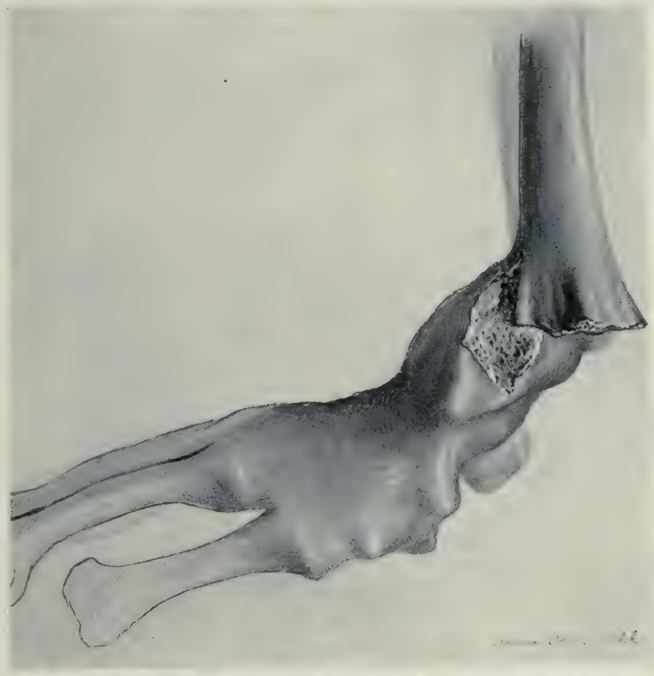


FIG. 97.—The broken lower end of the shaft of the radius is thrust forwards and the lower articular fragment in backward rotation is made to appear to have moved laterally.

Fracture without great displacement is often overlooked, and being regarded as a simple sprain is permitted to heal without effort to prevent deformity. In every case of injury to the wrist

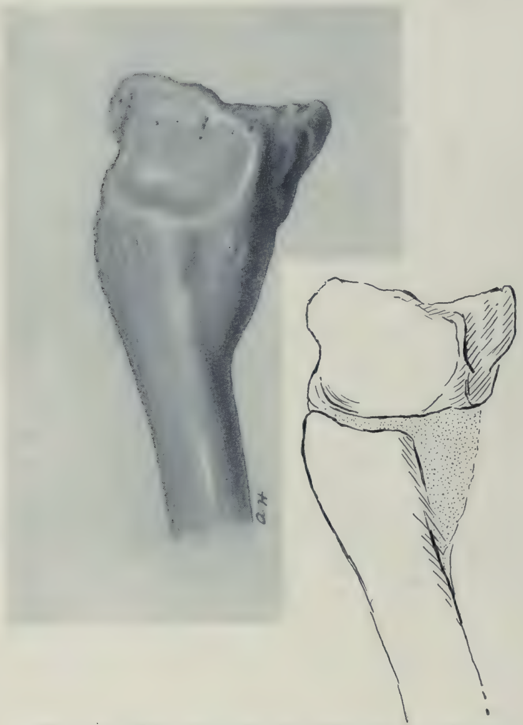
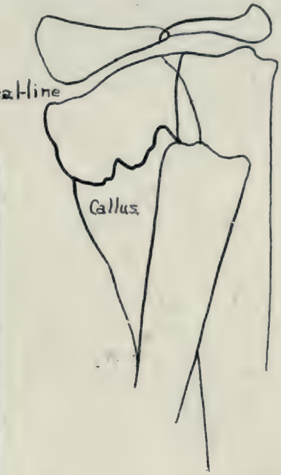


FIG. 98.—Repair after fracture of the base of the radius with unreduced backward and outward displacement of the lower fragment. From a specimen found in a dissecting-room cadaver. To illustrate especially the tendency to outward displacement of the lower fragment.

following violent backward flexion, accompanied with ecchymosis, local swelling and impairment of function, the presence of fracture is to be inferred, even though one fails to elicit any of the signs of it that have been mentioned.

The final authority as to the character and extent of the injury is the X-ray, and resort to it should be made whenever practicable both to confirm and correct the diagnosis and later to demonstrate the degree to which proper reposition of the fragments has been secured.



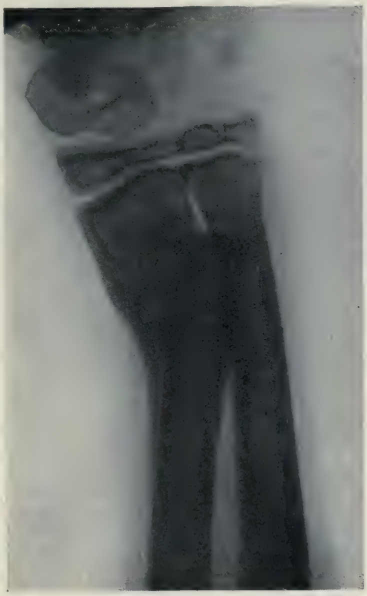


FIG. 99.—Transverse fracture three-fourths inch above articular surface in a youth. Lower fragment carried strongly outwards and backwards; no impaction; periosteum stripped up and angle filled with callus. See Fig. 86.

In all doubtful cases the information to be derived from the X-ray plate is most desirable and as a help to the surgeon in directing his treatment is invaluable. Both anteroposterior and transverse views should be taken.

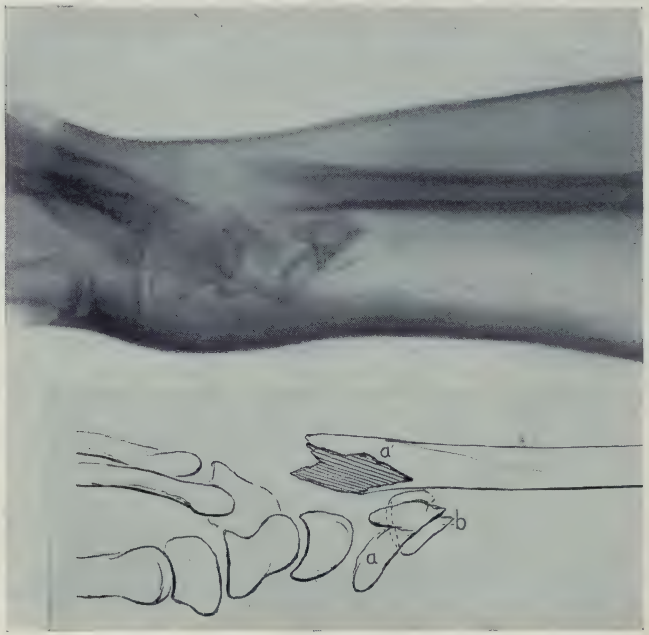


FIG. 100.—Fracture of the lower end of the radius and ulna with anterior displacement of the lower fragments. *a*, lower fragment of the radius; *a'*, fracture surface of lower end of shaft of radius; *b*, lower fragment of ulna. (Hitzrot, ANNALS OF SURGERY, June, 1915.)

Treatment.—If displacement exists its accurate reduction is of first importance. The chief obstacles to ready and perfect reduction are the impaction or entanglement of the uneven surfaces of the fragments, and the tension of the untorn periosteofibrous band which still unites them at the back. The latter can be overcome at once by placing the hand in dorsal flexion; while the hand is still in this position extension will disengage the fragments, and firm thumb pressure upon the back of the lower fragment will push it forward into place. This method of manipulation is well shown in Fig. 123.

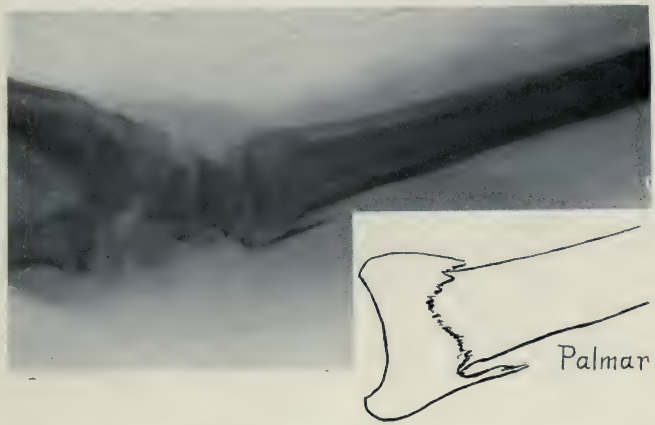


FIG. 101.—Transverse fracture with impaction of upper into lower fragment; fragment of articular segment displaced forward.

If the hand is then brought into palmar flexion while extension is continued and the thumb pressure on the back of the lower fragment is still maintained, the fragments come into normal relations, the fracture surfaces fall together and the normal contour of the bone is restored. Figs. 125 and 126 are from skiagraphs of a wrist of a woman who had slipped on the pavement and had received the brunt of her fall upon her extended hand. The fractures sustained are shown in Fig. 125. The amount of backward displacement was sufficient to produce a typical silver-fork deformity of the wrist, and to wrench off the styloid process of the ulna as shown in the skiagraph. I saw her within a few minutes after the accident and subjected the injured wrist to the manipulations described. The per-

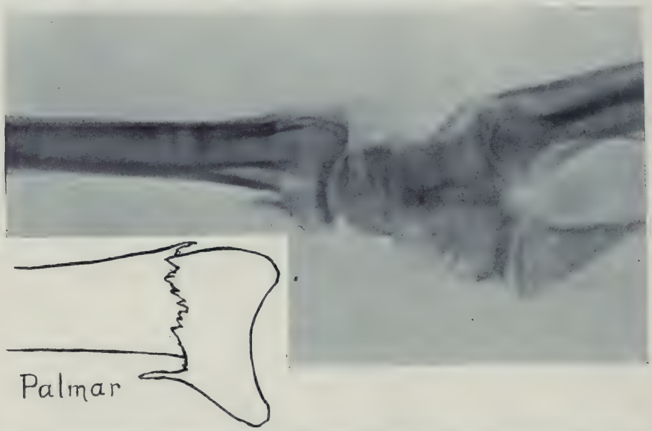


FIG. 102.—Lower fragment displaced forward, exaggerating the normal palmar projection of the anterior lip.

fection of the reposition is shown in the skiagraphs (Figs. 125 and 126) which were taken the next day so as to secure an X-ray record of the case. No general anæsthetic was required in this case to facilitate the reposition. Indeed I have rarely felt any need of such anæsthesia in dealing with a recent fracture of the wrist. If the patient is an hypersensitive or apprehensive individual or a child ether or chloroform will naturally greatly assist the surgeon in his manipulations. The displacement is to be overcome *arte, non vi.* The manipulations do not require the exercise of great force nor do they inflict excessive pain.

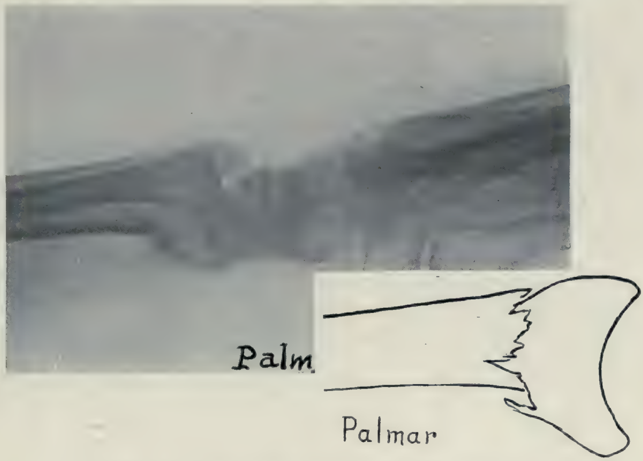


FIG. 103.—Anterior displacement of lower fragment.

Impaction of whatever degree is easily broken up after the tense, periosteal connecting band (see page 51) has been relaxed. If the impacting force has been great the lower fragment will be comminuted and the lower end of the upper fragment will in no sense be gripped by the pieces of the lower fragment by which it is surrounded.

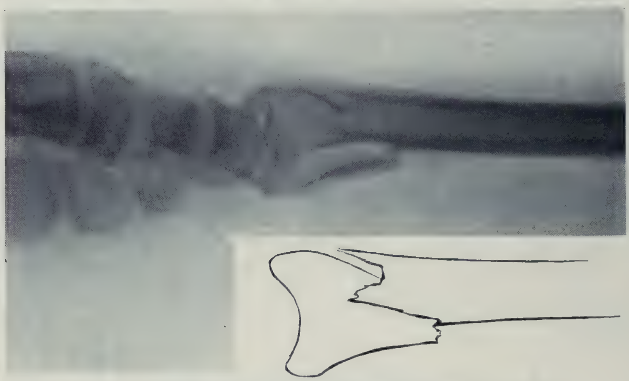
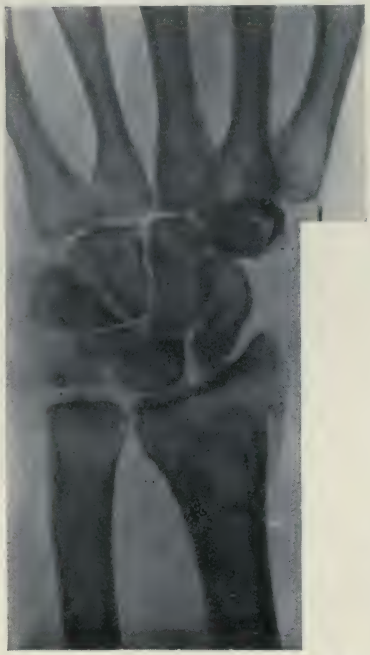


FIG. 104.—Anterior portion of lower fragment displaced *forward*. See anteroposterior view, Fig. 105.

If the lower fragment has been carried backward so far as to ride on the dorsum of the upper fragment—a not infrequent occurrence—all interosseous penetration is absent and the chief force that causes the displacement to persist is the tension of the stripped up dorsal periosteofibrous bands still holding the two fragments together (see Figs. 34, 70 and 90). It is not necessary to rupture these to any extent, if the manœuvres of relaxation as have been described are resorted to.



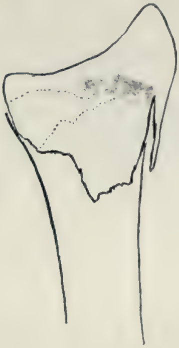


FIG. 105.—Lower fragment displaced forward; slight impaction of upper into lower fragment. Styloid process of ulna broken off.

These remarks apply particularly to the most frequent forms of displacement in which a backward movement of the lower fragment is the chief and most important element. In those rarer instances in which the upper fragment has telescoped the lower fragment in such manner as to split it and drive the pieces of the lower fragment in various directions, the best possible reposition of the fragments is to be secured by simple direct extension with approximation of the disrupted pieces by thumb and finger pressure, as in a moulding process.

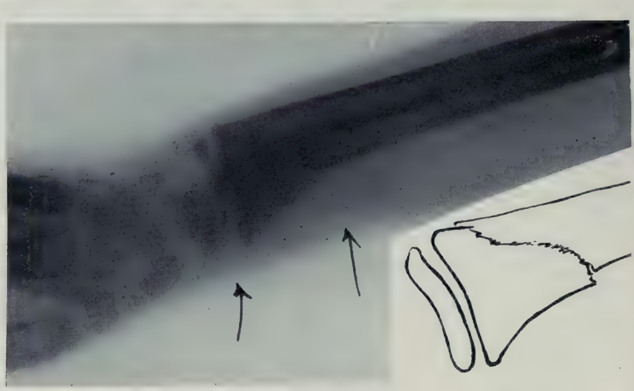


FIG. 106.—Oblique fracture in anteroposterior line of lower end of radius in a child seven years of age. One arrow points to the epiphysial line, one to the line of fracture.

Some permanent shortening of the radius from condensation of the tissue of the lower fragment is unavoidable in all cases in which the upper fragment is impacted in any degree into the lower one. Such shortening will make the end of the ulna more prominent on the inner side of the wrist; the greater the shortening of the radius the more prominent the ulna (see Fig. 122). Second only in frequency to the alteration in the plane of the carpal articular

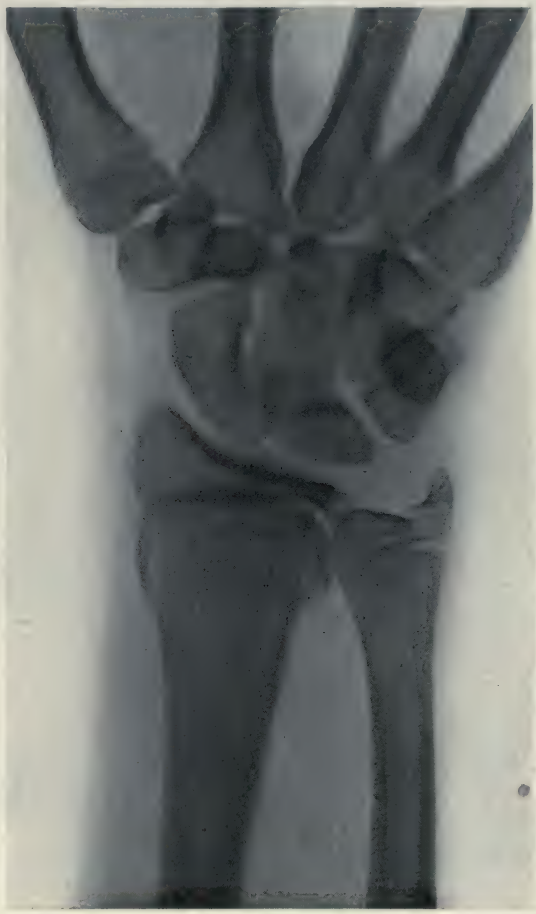


FIG. 107.—Separation of epiphysis with backward displacement. Lateral view (Fig. 87) shows moderate backward displacement of the radial epiphysis making an angle with the dorsum of the lower end of the upper fragment which is filled with callus.

surface of the radius (see page 26 and Figs. 77, 80 and 81), is this slipping away of the head of the ulna from its proper relation to the radius. The normal projection of the ulna on the dorsum of the back of the wrist disappears and an abnormal projection of it on the front and inside of the wrist persists permanently. The less the impaction and the more perfect the replacement of the lower fragment of the radius in its normal relation to the shaft of the bone the less the tendency of the ulna to show this deformity. In the further care of such a fracture attention will be required to secure and maintain full approximation of the ulnar head to its normal relation in the lateral articular facet of the radius until

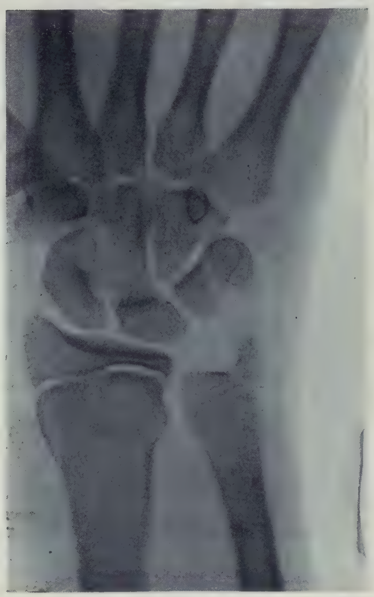


FIG. 108.—A lateral view of this case shows slight backward displacement of the epiphysis with line of fracture extending near posterior surface upwards into the substance of the diaphysis.

normal ligamentous bands have been reformed.

Ordinarily there is but little tendency to renewed displacement after reposition provided the part is protected from further direct force. Regard must always be given to the fact that any pressure brought to bear upon the palmar or anterior surface of the carporadial region will bear upon the projecting anterior lip of the lower fragment and may crowd that fragment back to the plane of the shaft of the bone (see Fig. 127) even though full restoration of the normal contour of the base of the radius had been secured by the surgeon before the retentive dressing was applied. Anteroposterior pressure also tends to crowd the soft tissues in between the radius and ulna, and, forcing the

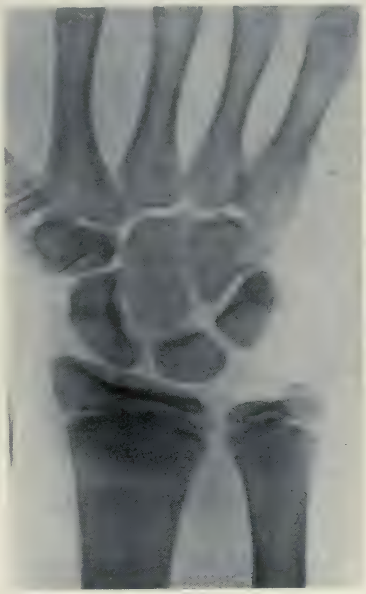


FIG. 109.—Lateral view shows the epiphysis torn off and displaced backwards for half the thickness of the bone.

ulna away, to renew and perpetuate its diastasis. The first indication in the planning of a retentive dressing therefore is the adaptation to the front of the forearm of a graduated pad of proper thickness so placed that it shall shield the anterior lip of the lower fragment from pressure (Figs. 128, 129 and 130). The lower margin of this compress should fall about one-half inch above the carpo-radial articulation. It should be about three-eighths of an inch at this lower edge, and should extend upwards from two and one-half to three inches. It should be wide enough to wrap part way around the ulna so as to give support to that bone also when the later circular roller is applied. A folded gauze compress answers fully for such a pad.

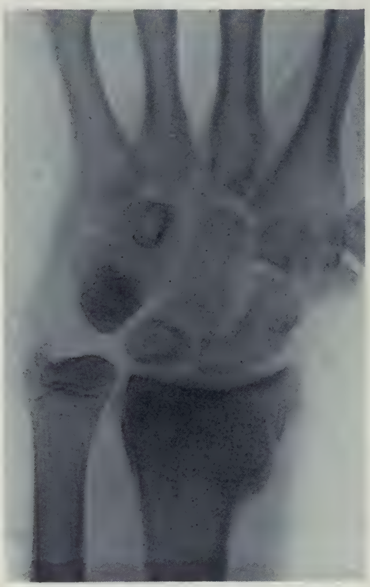


FIG. 110.—Epiphysial separation with backward displacement of the epiphysis—child of thirteen years. Dorsal angle filled with abundant callus. See Fig. 86.

In the further care of the injured part the indications are to give support and immobilization, with equable compression to limit effusion, and to maintain approximation of divided tissues while repair goes on. With the subsidence of the primary wound reaction precautions to maintain the mobility of the wrist and finger joints require attention. In very many cases, in addition to the graduated compress already mentioned, a flannel roller bandage and a sling will be all the apparatus required. The slightly elastic flannel roller binds the strained and shattered parts of the wrist together and gives an agreeable sense of security and support. At this first dressing allowance must be made for the

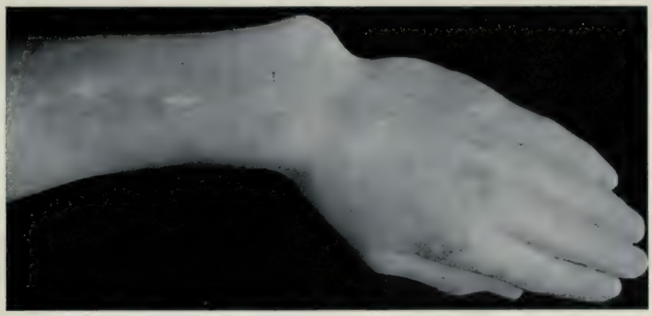


FIG. 111.—Deformity from obliteration of lower epiphysial cartilage of radius, following fracture of the base of the radius in a boy of twelve years; fragments put in good place and healed without deformity at the time. Gradual development of the condition shown in photograph with the growth to manhood of the boy; cast taken at age of thirty-two. Radius relatively short from lack of development in length; ulna prominent; hand inclined to radial side.

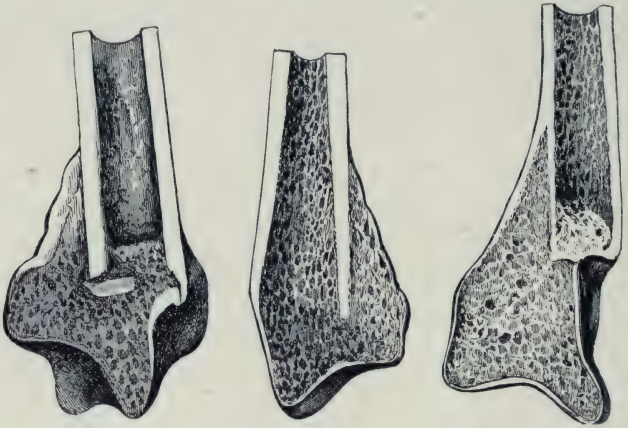


FIG. 112. FIG. 113. FIG. 114.

Sagittal section of old fractures of the lower extremity of the radius, healed in deformity, to show the results of the stripping up of the periosteum from the dorsum of the shaft; the subperiosteal space produced has been filled with callus which by its ossification mimics penetration of the cancellous lower end of the bone by the compact tissue of the shaft above. From Robert William Smith's Treatise on Fractures in the Vicinity of Joints, 1850, pp. 148, 149, 152 and 154.

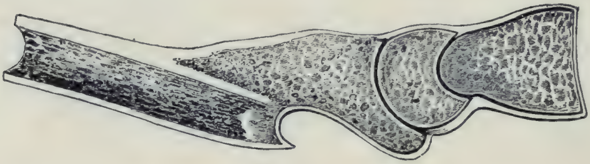


FIG. 115.

primary traumatic swelling that follows the injury, and the bandage must later be loosened or cut, whenever its constriction becomes a source of discomfort; as the swelling subsides it should be tightened again.

This circumferential compression is especially important to maintain the lower fragment and the carpus in their proper position to the ulna. It is further reinforced during the after-treatment by keeping the forearm supported on its ulnar side in a narrow sling, not extending forward beyond the distal end of the ulna, in which position the weight of the unsupported hand and wrist is an additional force tending to press the ulna into position.

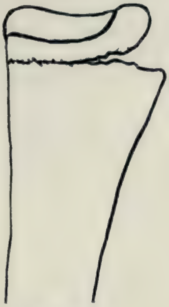


Fig. 116.

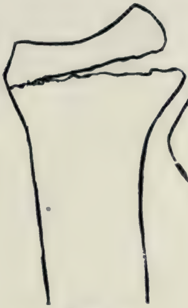


Fig. 117.

Incomplete fracture of the base of the radius. Diagrams constructed from skiagraphs.

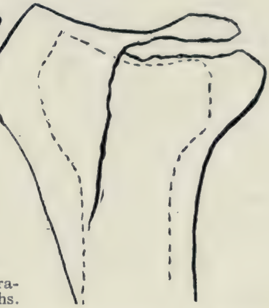


Fig. 118.

The feasibility of satisfactorily treating fractures of the base of the radius by so simple an apparatus as a flannel roller and a compress I learned very early in my experience in dealing with such fractures from the teaching of the late Dr. E. M. Moore, of Rochester, N. Y., who was led to it by his views as to the importance of supporting the ulna in the course of the treatment of such injuries.

Et moi
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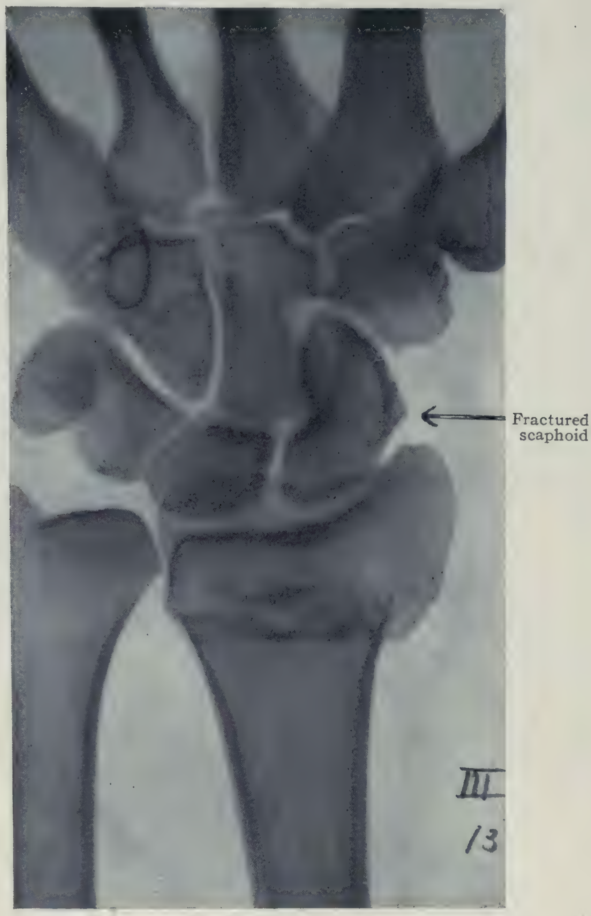


Fig. 119.—Fracture of the scaphoid bone, associated with transverse fracture of the base of the radius and fracture of the styloid process of the ulna.

In my earlier writings on this subject I emphasized the value of the method, advocating at that time an adhesive plaster strip encircling the wrist as the chief element of the apparatus required. In part this was one form of protest on my part to the wrongly applied and too prolonged use of immobilizing splints, almost universally employed in the treatment of this injury, to which I was convinced that much of the unfortunate results so often attending this fracture were due. I have treated a large number of broken wrists during the past thirty years without the use of a splint with such good results that they have fully justified me in the practice. Nevertheless, I have not been unmindful of the distinct advantage of the protection which a properly applied splint could give in these injuries, a protection which is more especially called for in the presence of much comminution of the lower fragment, and in those cases in which marked displacement demonstrated the association of extensive sprain and laceration of the soft parts.

Whether indeed to the dressing should be added a splint will generally depend upon what may be called collateral circumstances. In cases of those who are young, or are careless or are apprehensive, the additional protection of a

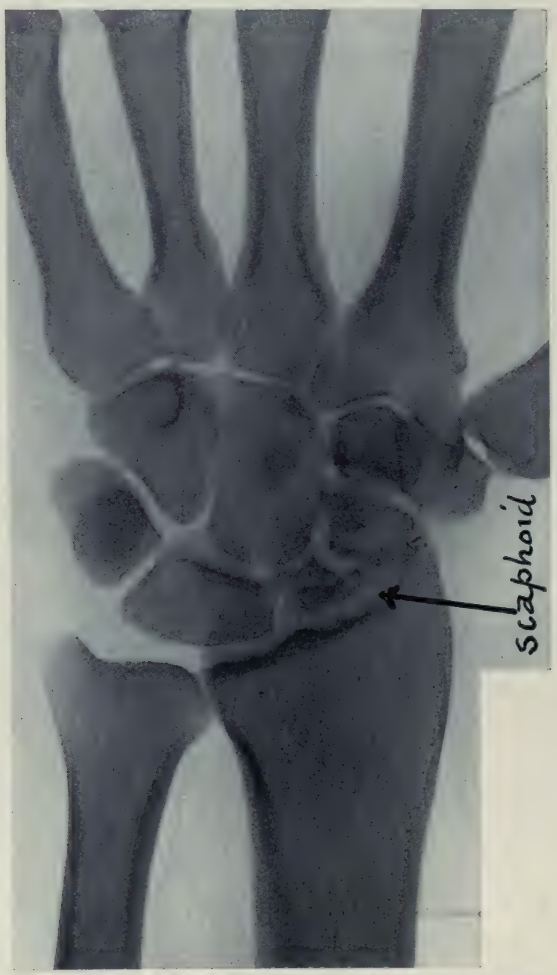


FIG. 120.—Fracture of the scaphoid bone, produced by an automobile crank "kick-back."

splint is a wise precaution to be used if the surgeon also remembers that its prolonged use may create finger and wrist stiffness and by its pressure deformity may be perpetuated or an ischæmic paralysis may be induced. For a young surgeon also it will in most cases be more discreet not to disregard the popular sentiment as to the necessity of a splint in the treatment of a fracture. If a splint is to be used a light straight posterior splint supplies fully all the indications for splint support and immobilization (Fig. 129). It should not be wider than the wrist itself lest it interfere with the lateral support to the ulna; it should extend from the upper part of the forearm downward only to the heads of the metacarpal bones, so that the fingers shall not be confined by it. It should be well padded. The graduated pad to fill up the concavity of the radius above the articular lip on the palmar side will already have been adjusted as recommended (page 96), shown also in Figs. 128 and 129.

Special support to the ulna should be given by making the palmar pad wide enough to project on the inner side of the wrist sufficiently to enwrap the inner side of the ulna, or by the adaptation of a special pad to support the ulna. Over all should be applied a roller ban-

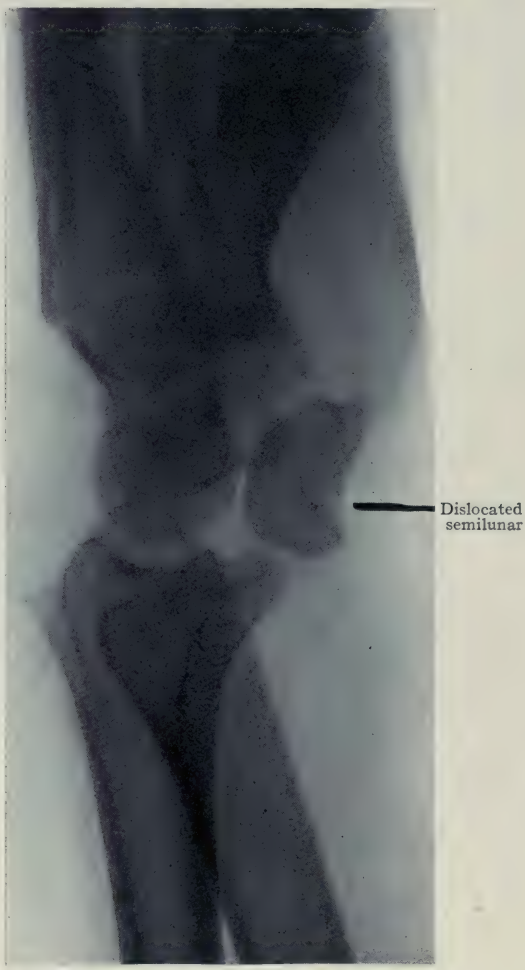


FIG. 121.—Dislocation forward of the semilunar bone, produced by an automobile crank "kick-back."

dage—preferably of flannel—which should leave the fingers and the thumb free. As soon as the primary congestive reaction from the injury has subsided, that is, from the fourth day, the thumb and fingers should be frequently and systematically flexed, and after the first week the splint should be daily removed and the wrist should be massaged and moved; by the end of the third week the splint should be discarded altogether, and thereafter active and passive movements of the wrist and fingers, with massage, be practised systematically until the normal function of the parts has been restored.

Special Forms of Splints.—Many special forms of splints have been devised for this injury, most of them intended to maintain certain positions of the hand on the supposition that thereby displacements could be corrected or prevented. They are with few exceptions based on incorrect views as to the cause of displacement and disability and none of them possess such special advantage as to justify their description here. An exception to this statement may be made in the case of such splints as the Coover, the Levis and the Walker splints which are anterior splints molded in such a way as to accommodate the irregularities of the palmar side of the hand, wrist and forearm, and hence tend to lessen

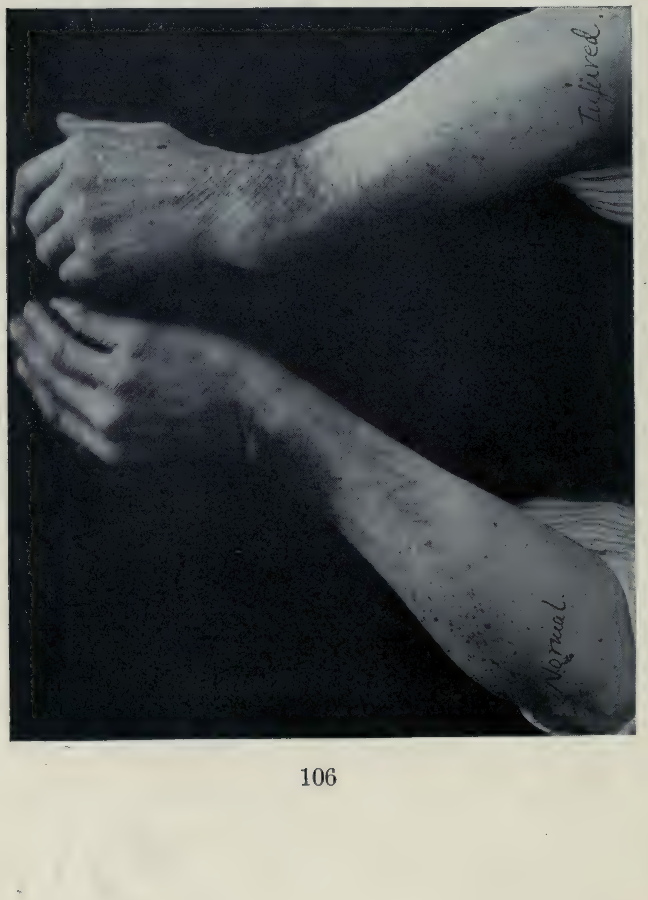


FIG. 122. — Prominence of ulna and shortening of radius, after fracture of lower extremity of radius with marked backward displacement of lower fragment (see Figs. 61 and 96).

the disadvantages of the ordinary straight anterior splint. With proper padding (Fig. 130) they may be made to give the needed support to a fracture without exerting undesired pressure on the anterior face of the lower fragment, and they are comfortable to the patient. One who wishes to use these splints must have a variety of sizes—rights and lefts—to adapt them to various ages and sizes of patients. Their use does not in any degree lessen the importance of first fully readjusting the fractured parts. It is only after full reposition has been secured that they may help in the further care of the case. In 1881 Dr. Coover, of Harrisburg, Pa., sent me a full set of various sized splints, devised by him, so shaped out of light pine fabric that the thenar eminence of the hand and the normal lateral angle of the hand with the forearm were provided for (see Fig. 131). During the thirty-five years that have elapsed since I received them, I have used these splints many times; I have most of them still in good condition for I have seen to it that they were not carried away permanently by those in whose cases they were used. The manner of their application is shown in Fig. 132.

Treatment of Fractures Already Healed in Deformity.—It is not infrequent that fractures of

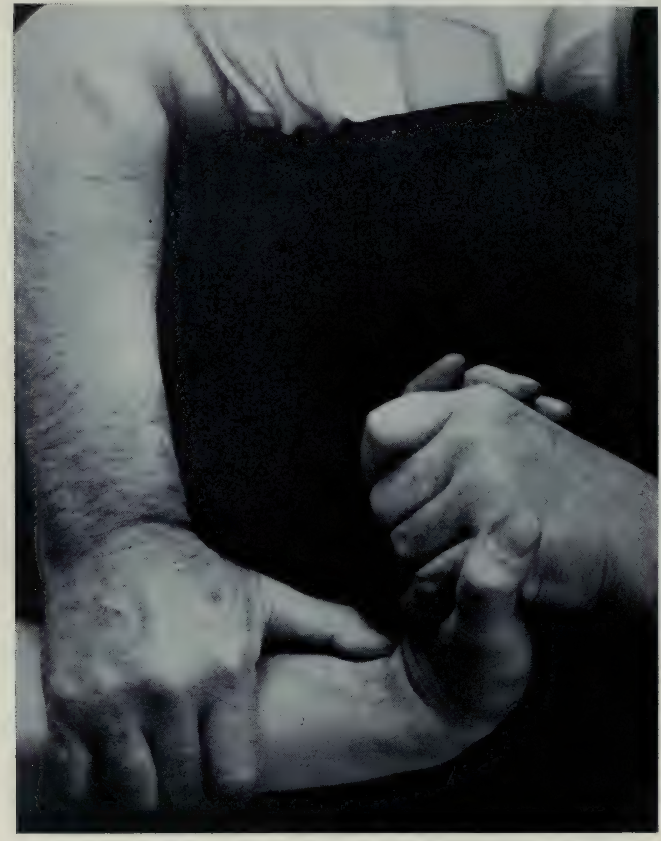


FIG. 123.—Dorsal hyperflexion with extension of disengaged lower fragment.

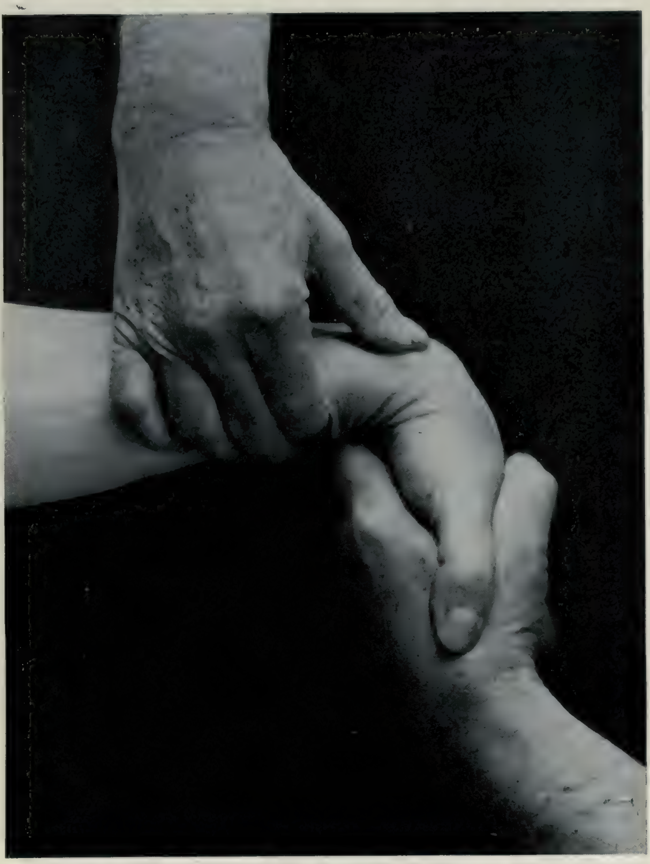


Fig. 124.—Extension continued, thumb pressure on back of lower fragments; final palmar flexion.

the base of the radius are permitted to heal without adequate effectual attempts at adjustment of the primary traumatic deformity having been made. Every grade of the deformities which have been recognized as due to any degree of this injury may remain as the permanent result. In general the functions of the wrist and hand

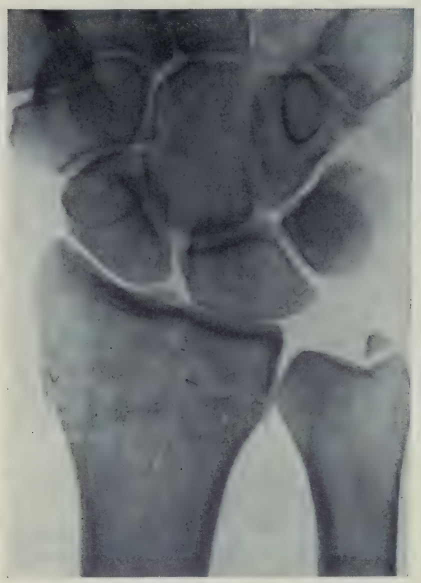
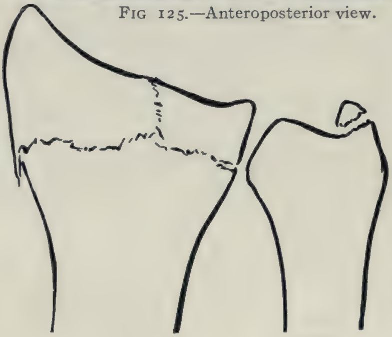


FIG 125.—Anteroposterior view.



FIGS. 125 and 126.—Fracture of base of radius with comminution and backward displacement of lower fragment of radius with moderate impaction. Skiagraph taken after reposition to show final adjustment of the fragments secured. Note the persisting slight change in the plane of the carpal articular surface of the radius due to the mutual compression of the bony lamellæ along the posterior portion of the fragment at the point marked by the star.

are ultimately so far restored, even in cases of marked deformity, that all the ordinary activities and possibilities of usefulness of the member are regained. The greatest and most prolonged disabilities are due to adhesions in the tendon-sheaths and among periarticular fibrous structures and to muscular degenerations caused by undue and prolonged splint pressure and immobilization and not to the bony malformation.

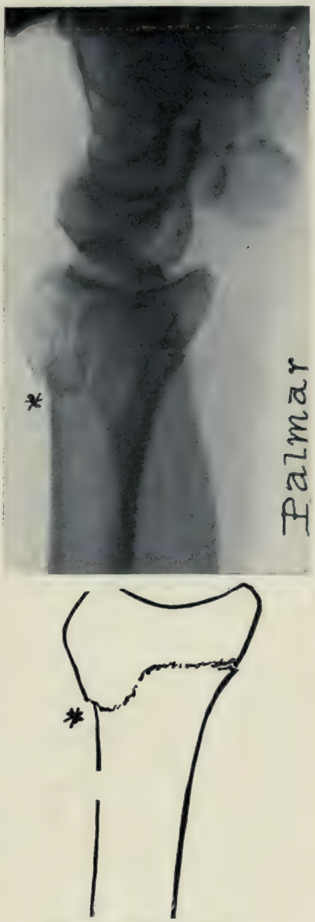


FIG. 126.—Transverse view.

In comparatively recent cases, by that I mean at periods of from three to six weeks after injury, there still remains ground for hope that by breaking up the new formed and still soft bonds of union, either by manipulation or by a chisel through an open wound, a better position of the fragments could be obtained and the worst of the deformity removed. When, however, one reflects as to the frequency with which permanent alterations in the texture and contour of the lower fragments have unavoidably resulted from the injury sustained, and also how extensive are the contractures of the periarticular tissues and the ruptures of ligaments that cannot be reformed as before the injury, one will not be too sanguine as to the ultimate benefit which he may secure to such a patient by operative interference. In a number

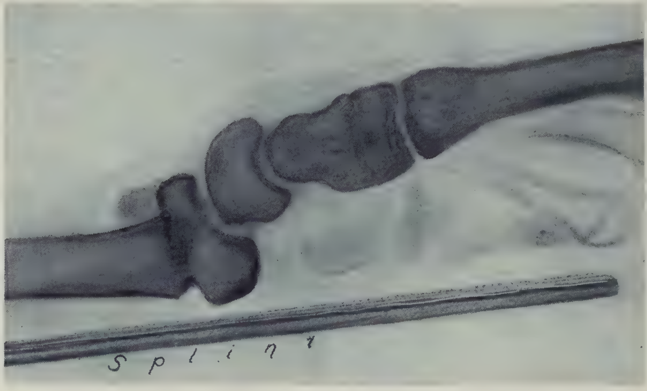


FIG. 127.—Showing effect of palmar splint to maintain or reproduce backward displacement of the lower fragment after fracture of base of radius. From a skiagraph taken three months after injury; original backward displacement still unreduced; fracture healed with deformity.

of instances I have exposed a badly united fracture line involving the base of the radius by an incision over the dorsum of the radius reaching from the middle of the carpus below upwards as far as required to secure needed exposure and

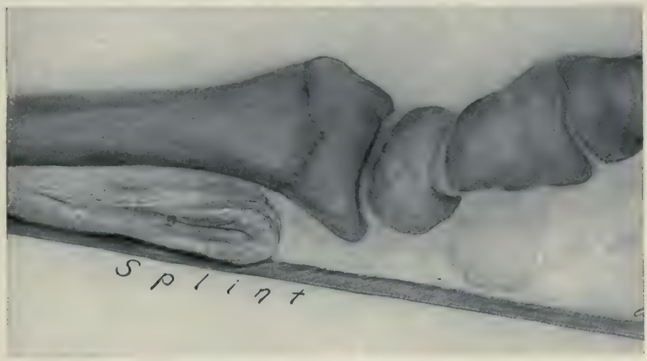


FIG. 128.—Showing position and shape of special palmar pad to protect from pressure productive of backward displacement the lower fragment of a fractured radius involving the base.

access to the seat of the fracture for the necessary manipulations. By blunt dissection the lower end of the bone can be readily exposed; the periosteo-ligamentous-tendinous flaps can be held aside by retractors, and a chisel used as freely as may be necessary to re-establish the fracture in its original plane. The surrounding restricting fibrous bands will have to be divided with sufficient freedom to make possible the easy replacement of the loosened lower fragment in its

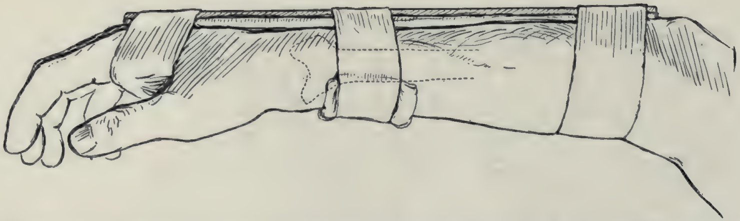


FIG. 129.—Diagram to show the adaptation of a straight splint to the dorsum of the wrist. Note the even plane of the dorsal surface of forearm, wrist and hand requiring minimum amount of padding; note the projection to the palmar side of the articular lip of the base of the radius; note the pad adjusted to the concavity of the palmar surface of the base of the radius and secured so as to shield the articular lip from pressure that may displace it backwards if separated by fracture.

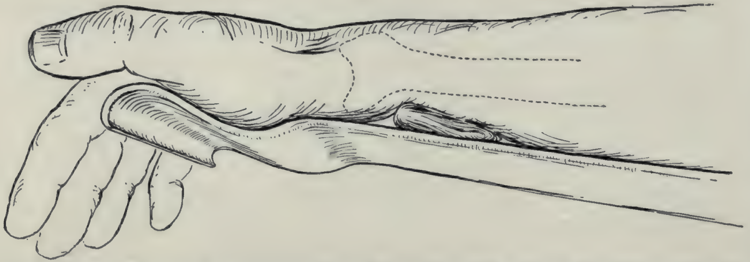


FIG. 130.—Diagram showing adaptation of the turbinated splint to the conformation of the hand, wrist and forearm. Note the use of a compress to lift the projecting lower margin of the articular expansion of the base of the radius from the pressure of the splint.

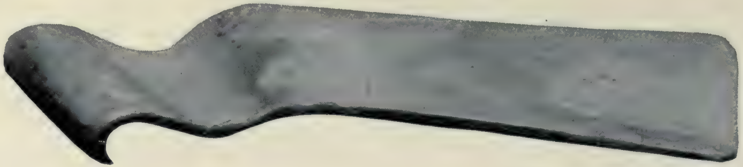


FIG. 131.—The turbinated splint (Coover) for fracture of the lower extremity of the radius and other injuries of the wrist.

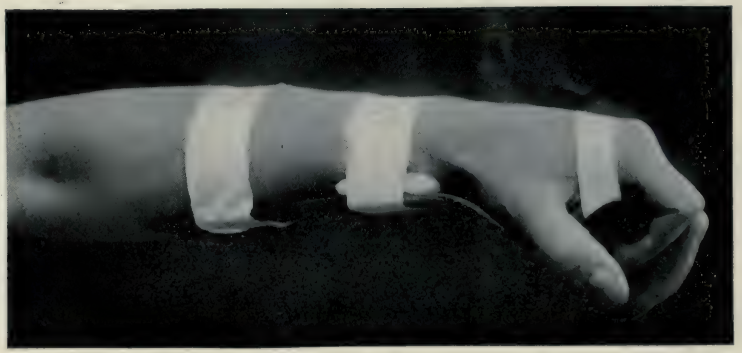


FIG. 132.—Palmar turbinated splint applied. Note thenar eminence received in the depression provided for it; note projecting anterior lip of radius secured from pressure by special compress adjusted; note support given by encircling adhesive strip to prevent tendency to renewed backward displacement of the lower fragment; note freedom of thumb and fingers for active movements.

normal position and prevent any tendency for it to be drawn again into its faulty position. This having been accomplished, the wound is sutured and the part dressed and cared for as if a recent fracture. The results of such attempts at my hands have been sufficiently good to encourage their repetition in similar cases. I have thought that I have not been sufficiently free in dividing the periarticular fibrous structures in some of them to have secured as perfect a result as might possibly have been attained. I have not had occasion to resect a projecting ulnar head, but it cannot be denied that such a procedure would be indicated in some cases.

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